COOPERATIVE
IMPACT ASSESSMENT
REPORT

THE BIOLOGIC AND ECONOMIC ASSESSMENT OF

CARBOFURAN

United States
Department of
Agriculture

In cooperation with

State Agricultural
Experiment Station

Cooperative Extension

Other State Agencies

U.S. Environmental
Protection Agency

Technical Bulletin
Number XXXX

THE BIOLOGIC AND ECONOMIC ASSESSMENT OF

CARBOFURAN

A report of the Carbofuran Assessment Team
to the Special Reivew of Carbofuran

Submitted to the Environmental Protection
Agency on December 22, 1989

United States
Department of
Agriculture

In cooperation with

State Agricultural
Experiment Station

Cooperative Extension

Other State Agencies

U.S. Environmental
Protection Agency

Technical Bulletin
Number XXXX

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The purpose of this assessment report is to produce an accurate and objective overview the biological and economic information relative to the benefits and uses of carbofuran in agricultural productivity in the U.S. and to examine the social and economic impacts of the present and continued use of carbofuran.

The Office of Pesticide Programs of the U.S. Environmental Protection Agency (EPA) has issued a Notice of Special Review of granular pesticide products containing carbofuran. These products are manufactured by the FMC Corporation marketed under the trade name Furadan. A Special Review is the process by which EPA initiates review of pesticide products, leading to an ultimate determination of whether their use of uses pose unreasonable adverse effects to humans or the environment.

The National Agricultural Pesticide Impact Assessment Program (NAPIAP) established a review group in November 1988 to evaluate the impact of the proposed action on agriculture and furnish advice and information to EPA.

SPECIAL REVIEW TRIGGER (EPA)

The Environmental Protection Agency is examining the use of granular carbofuran because of its suspected hazard to birds.

GENERAL

Granular carbofuran is a carbamate insecticide and nematicide usually applied at the beginning of the growing season at planting time. Applications of this material may also be made later in the season depending on crop and pest problem. In this assessment, the committee was concerned mainly with 2,3,5,10 and 15 percent active ingredient granular product although there are flowable and wettable powder formulations available. This product is a restricted use pesticide based on avian toxicity.

Carbofuran is a cholinesterase inhibitor but is rapidly metabolized by animals into less toxic and finally non-toxic metabolites. Carbofuran is systemic in plants. It was first registered in 1969 by FMC Corporation.

Current available acute toxicological studies on carbofuran show the following:

- Acute oral toxicity: rat, LD50 3.8-34.5 mg/kg; mouse,

  LD50 14.4 mg/kg cat, 2.5 - 3.5 mg/kg; dog, LD50 15-18.9 mg/kg (Tox Category I)

- Acute dermal toxicity: rabbit, LD50 in isopropanol

<46.4; LD50 in water >10,250; 75WP formulation LD50 in water, 3400 (Toxicity Cateogry I)

- Acute inhalation: (dust) rat. 1 hr. LD50 0.80 - 0.108 mg/L; rat 4 hr. LD50 0.075-0.108 mg/L; rat. 1 hr. LD50 >0.026 mg/L; rat, LC50 4 hr. 0.017 - 0.046 mg/L (Toxicity Category I)

Reproductive Effects/Teratogenicity: Daily feeding of 100 ppm of carbofuran to pregnant rats greatly reduces the ability of the pups to survive. 100 ppm is similar to 1 oz. of salt on 32 tons of potato chips. Mice pups show non-fatal liver changes. The lowest amount of carbofuran that proved teratogenic to mice in the mother's diet (TDlo) was 210 ug/kg (fed throughout pregnancy).

Mutagencity: No mutagenic effects reported in animals or bacteria *using the Ames Assay). Genetic changes have been shown in algae, though.

Carcinogenicity: No such effects found reported. However, N-nitrosocarbamates are potent mutagens and carcinogens. They can be made under the acidic conditions of the stomach of some animals. Humans are possible candidates.

Organ Toxicity: No information found.

Fate in Humans and Animals: Carbofuran is poorly absorbed through the skin. It is metabolized in the liver and eventually excreted in the urine. The half-life is from 6-12 hours. About 3% of the mother's intake will be excreted in the milk. Carbofuran is highly acutely toxic to birds and a single granule may kill a small bird.

A questionnaire developed to assess the benefits of carbofuran and the risks to birds was designed to elicit key information regarding the present use of carbofuran. A computer software program was also developed to help with the economic assessment of carbofuran. Each state was requested to complete a questionnaire for each crop/site for which the pesticide was used in significant quantities. Data were collected relating to the averages of production, costs, and use of carbofuran through 1988. Questionnaires were sent to each of the 50 states plus territories of the United States. Responses were received from all 50 states as well as Puerto Rico and the Virgin Islands; and the results serve as the basis of this assessment.

A questionnaire was developed to determine documentation or knowledge of wildlife mortality related to pesticides. This survey was sent out to 336 individuals with 196 responses returned.

The recommendations contained herein are based on the assumption that the alternatives (pesticides) listed for specific site/pest/crop use remain viable. Loss of registration or availability of these alternatives to carbofuran would require re-examination of recommendations listed below.

Based upon the results of the benefits analysis the continued registration of carbofuran on the following sites is considered essential:

a. Bananas- in Hawaii, carbofuran is the only registered pesticide known to provide effective control of the banana root borer. It is estimated that there would be an 85% yield loss in production of bananas if carbofuran is lost.

b. Rice- carbofuran is the only labeled insecticide for the control of the RWW (rice water weevil), the US's most damaging insect pest of rice. Depending on the price of rice received by producers, the annual benefit of carbofuran to U.S. rice farmers is estimated between $24.5 million and $48.7 million.

c. Cranberries- especially in the Pacific Northwest- this is the only material that works for control of the black vine weevil. If carbofuran was lost, an estimated loss of 5% of the current NW cranberry acreage could be lost per year.

d. Grain Sorghum- Furadan 15G is needed for chinch bug control in the states of Kansas, Nebraska, Texas, Mississippi, Louisiana, and Oklahoma. Alternative pesticides are either more costly or much less effective.

Continued analysis of carbofuran on other registered crops yielded the following results.

a. Corn- only a small percentage of the corn acreage, mostly in the south, is treated with carbofuran. The major problem with loss of carbofuran to corn growers would be the problem of pest resistance management. Carbofuran is the only carbamate soil insecticide used and its elimination would exclude a whole chemical class from the rotation scheme as a management tool. Price changes and consumer losses would be negligible.

b. Curcubits- Most states feel that there are alternative pesticides for carbofuran. However, there are concerns regarding pollinator toxicity with those alternatives. A yield decrease is estimated if carbofuran should be lost resulting in a monetary loss of $2.3 million.

c. Sugar beets- There are alternatives to carbofuran on sugar beets, however, many of them are under special review. If carbofuran is lost, producers would lose about $1.1 million.

Very little or no carbofuran is used on or negligible impact from loss of carbofuran would occur on the following crops:

Tobacco- 14 percent of tobacco acreage is treated but there

are alternatives.

Alfalfa- less than 0.1 percent of total U.S. alfalfa acreage is treated.

Pineapples- no carbofuran used.

Cotton- less than 1 percent of total U.S. cotton acreage is treated.

Sugar cane- 6 percent of crop treated; economic loss of about $190,000 per year without carbofuran.

Potatoes- less than 2 percent of total U.S. potato acreage is treated.

Peanuts- the only negative impact would be on Virginia peanut growers, where there would be a monetary loss of $0.6 million.

Soybeans- alternatives available less than 0.1 percent total soybean acreage is treated.

Strawberries- carbofuran granular formulations are not used.

Grapes- very little used.

Peaches & Nectarines, nonbearing- producers would lose about $136,000.

Ornamentals- important in localized areas. More information will be collected by a special ornamentals group.

No information was collected on carbofuran use on peppers, sunflowers, forest-seed and small grains.

WILDLIFE

The summary data indicate that in only 4 of 30 incidents where wildlife loss occurred was granular carbofuran believed to have been applied according to label directions. In the other instances, applicators either misapplied the pesticide in some manner, or the product was deliberately misused for the purpose of poisoning depredating wildlife. Inasmuch, as number of survey returns was deemed very good and geographic coverage of responses was also excellent, we believe this survey to be as complete a picture as can be obtained from such state and federal agency personnel nationwide who are likely to have knowledge and/or records of carbofuran hazards to wildlife. Thus, for all reported incidents involving wildlife believed poisoned by carbofuran, 26 of the 30 incidents (86.7%) occurred when label directions were not followed. On the basis of this survey, we conclude that carbofuran use, when application conforms to current labels, appears to result in negligible hazard to wildlife. Further, when such hazards have occurred, it appears to have been when incorporation of the material was absent or

incomplete.

"Survey data obtained by the Benefits Assessment Team from crop and commodity specialists throughout the U.S. indicate that there is not great environmental concern among this group about continued use of granular carbofuran formulations. A thorough survey of state and federal agencies for documented records of wildlife kills caused by carbofuran revealed that in most instances where hazards had occurred, the product was misused and the label directions were violated, either accidentally or purposefully. Little or no evidence was obtained to document that granular carbofuran, when applied and incorporated according to label directions, causes anything other than incidental mortality of wildlife. Such data indicate to use that carbofuran use, as currently practiced in American agriculture, poses little hazard to populations of birds or other wildlife."

For most crops, the economic effect of banning carbofuran would be small because effective alternatives are available. However, many of the pests controlled by carbofuran are potentially very damaging. The benefits of all alternatives used to control those pest is high while the benefit of any single alternative is low. Banning carbofuran would reduce the number of effective alternatives. This effect becomes important if some of the alternatives have health or environmental problems that could justify removal from the market. If enough alternatives are removed, the benefits of the remaining alternatives will become very high. So, if carbofuran were the only alternative remaining on the market, its benefits would be very high.

An important example is the control of soil insects on corn. EPA is considering at least two granular alternatives, phorate and terbufos, for special review. The cumulative effect of banning all three insecticides is unknown. While the effect of banning only carbofuran would be negligible, experts estimated that uncontrolled corn rootworms could reduce average corn yields by 12 percent on treated acreage in 6 States. Osteen and Kuchler (1986) estimated that the loss from banning all soil insecticides would be $2.2 billion. While corn producers could suppress rootworms by rotating, they would lose income by rotating to crops generating less income. Commodity program participants could reduce base acreage and program payments.

Sugar beets are another example. Aldicarb, terbufos, and phorate are three alternatives that EPA might remove from the market. Banning only carbofuran would have little impact on yield, although costs would increase $18 per treated acre. Without control, sugar beet root maggots would reduce yields on 55 percent of the acreage by 24 percent and also reduce quality.

The few problems associated with carbofuran use and bird kills in the past could be eliminated by better application techniques. Most of the problems associated with carbofuran, too much uncovered granules left at the beginning and end of the rows and improper soil incorporation, could also hold true for other granular pesticides. Therefore, the solution is not through the cancellation of carbofuran granules, but through the development

of better application equipment. FMC and Clampco Company have both been working on application equipment that has instantaneous shut offs, which would eliminate uncovered pesticide granules which the birds pick up. Also better enforcement of placing and timing of applications would eliminate incorporation problems.

Much of the application of carbofuran at the high rate of active ingredient has nematacidal activity as well as insecticidal. If the low rate (one pound active ingredient per acre) is adopted, then carbofuran will have no nematacidal activity and the uses of other nematicides will most likely increase.

COOPERATIVE EFFORT STATEMENT

This report is a joint project of the U.S. Department of Agriculture, the State Land-Grant Universities, and the U.S. Environmental Protection Agency. This report is prepared by a team of scientists from these organizations to provide sound, current scientific information on the benefits of, and exposure to, carbofuran.

The report is scientific presentation to be used in connection with other data as a portion of the total body of knowledge in a final benefit/risk assessment under the Review process in connection with Federal Insecticide, Fungicide, and Rodenticide Act as Revised in October 1988.

Sincere appreciation is extended to the Assessment Team members and to all others who gave so generously in the development of information in preparation of the report.

CARBOFURAN ASSESSMENT TEAM

Jack E. Bailey	Peanuts	North Carolina State University Raleigh, North Carolina
Barry M. Brennan	Pineapples Bananas	University of Hawaii Hawaii, Hawaii
Vernon E. Burton	Alfalfa	University of California Davis, California
Donald C. Cress	Corn	Kansas State University
James F. Dill	Team Leader	University of Maine Orono, Maine
R.A. Dunn	Potatoes	University of Florida Gainesville, Florida
Glenn C. Fisher	Cranberries	Oregon State University Corvallis, Oregon
John J. Gallian	Sugar Beets	University of Idaho Twin Falls, Idaho
Peter B. Goodell	Cotton	University of California Davis, California

Al A. Grigarick	Rice	University California Davis, California
George Hamilton	Curcurbits	Rutgers University New Brunswick, New Jersey
William R.A. Lambert	Cotton	University of Georgia Tifton, Georgia
Donald G. Manley	Tobacco	Clemson University Florence, South Carolina
Craig Osteen	Economics	Economic Research Service Washington, DC
Dale K. Pollet	Sugar Cane	Louisiana State University Baton Rouge, Louisiana
John Radewall	Ornamentals	University of California Riverside, California
Larry E. Sandvol	Potatoes	University of Idaho Aberdeen, Idaho
Gary J. San Julian	Wildlife	North Carolina State University Raleigh, North Carolina
George A. Schaefers	Strawberries	Cornell University Geneva, New York
John C. Smith	Soybeans	Tidewater Research & Continuing Ed. Center, Sullfok, Virginia
John K. Springer	Non-Bearing Peaches	Rutgers University Bridgeton, New Jersey
Kevin Steffy	Corn	University of Illinois Champaign, Illinois
J.W. Stewart	Sorghum	Texas A&M University Uvalde, Texas
Harold Stockdale	Soybeans	Iowa State University Ames, Iowa
John Taylor	Forest-Seed	USDA Forest Service Atlanta, Georgia
Robert M. Timm	Wildlife	University of California

		Hopeland, California
H. Don Tilmon	Economics	University of Delaware Newark, Delaware
Lee H. Townsend	Tobacco	University of Kentucky Lenington, Kentucky
Dave Walgenback	Small Grains	South Dakota State University Brookings, South Dakota
Michael O. Way	Rice	Texas A&M University Beaumont, Texas
L.H. Waters	Grapes	Washington, DC
John L. Wedberg	Alfalfa	University of Wisconsin Madison, Wisconsin
James R. Weeks	Peanuts	Auburn University Headland, Alabama

PURPOSE OF THE REPORT

This pesticide use assessment is an integrated document containing deatiled information as well as general conclusions and recommendations. The purpose of the assessment is to produce an accurate overview of the uses of carbofuran, benefits of those uses to agricultural productivity, and economic and social impacts of the present and continued uses. This assessment is accomplished by a multi-faceted team of scientist drawn from the agricultural scientific community. The information is examined in a highly integrated manner and presented in this report. The information is divided into two broad categories as follows:

* An examination of present uses of the pesticide along with an overview and evaluation of alternative pest management programs. This evaluation encompasses benefits to agricultural productivity and quality of agricultural products and social, environmental and ecomonic benefits and impacts.

* An overview and evaluation of exposure levels resulting from uses of the pesticide in question. This evaluation is not a risk assessment, but an exposure analysis using known facts related to uses and cropping systems. The purpose is to relate theoretical risk to actual exposure resulting from present uses of the pesticide.

The Office of Pesticide Programs of the U.S. Environmental Protection Agency (EPA) has issued a Notice of Special Review of granular pesticide products containing carbofuran. These products are manufactured by the FMC Corporation marketed under the trade name Furadan. A Special Review is the process by which EPA initiates review of pesticide products, leading to an ultimate determination of whether their use of uses pose unreasonable adverse effects to humans or the environment.

The National Agricultural Pesticide Impact Assessment Program (NAPIAP) established a review group in November in November 1988 to evaluate the impact of the proposed action on agriculture and furnish advice and information to EPA.

In the document that follows, we present a description of the methods used by the Assessment Team in acquiring and analyzing data on carbofuran use and benefits followed by a thorough discussion of uses deemed significant based on the amount of crops/acreage treated per year. For each use, we identify the specific target insects and identify potential

alternatives to carbofuran use. Finally, we present an analysis of the economic and social impacts of carbofuran use and a discussion of the consequences of carbofuran not being available.

SPECIAL REVIEW TRIGGER (EPA)

The Environmental Protection Agency is examining the use of granular carbofuran because of its suspected hazard to birds.

ACKNOWLEDGEMENTS

We wish to thank all individuals that responded to our surveys. Listed below are the respondents. We hope we have acknowledged everyone who responded. If your name does not appear here, we also wish to thank you. We also wish to thank Donna Buckley, Pest Management Secretary, who spent countless hours typing this manuscript.

RESPONDENTS TO CARBOFURAN ASSESSMENT (Furadan 15G)

State	Name	University
Alabama	William S. Gasaway	Auburn University
	Ron Weeks	
	John C. French	
Alaska	Ronald Smith	Alaska
Arizona	Paul Baker	University of Arizona
	Donna Scherban	
Arkansas	M.C. McDaniel	University of Arkansas
California	Vernon E. Burton	University of California
	John Radewald	
Colorado	Bert L. Bohmont	Colorado State University
	Frank B. Peairs	
Connecticut	Candice Bartholomew	University of Connecticut
Florida	O.N. Neisheim	University of Florida
	Richard Sprenkel	N. Florida Res. & Education
Georgia	William M. Powell/David B. Adams	University of Georgia
	Herbert Womack	Rural Development Center
Hawaii	Barry Brennan	University of Hawaii
Idaho	Gene Carpenter	University of Idaho
Illinois	Kevin Steffey	Ill. Nat. History Survey
Indiana	C. Richard Edwards	Purdue University
Iowa	Harold Stockdale/Laura Sweets	Iowa State University
Kansas	Randall A. Higgins/Doug Jardine	Kansas State University
	Leroy Brooks	
Kentucky	Richard E. Stuckey	University of Kentucky
	D.W. Johnson	
Louisiana	Jerry Graves	Louisiana State University
	Jack Baldwin	
Maine	James Dill	University of Maine
	Glen Koehler	
Maryland	Galen Dively	University of Maryland
	Amy Brown	
Michigan	George W. Bird	
	Larry G. Olsen	
Minnesota	Phillip Harein	University of Minnesota
Mississippi	Jim Hameil	Mississippi St. University

Missouri	Alan Schreider	University of Missouri, Col.
Montana	Greg Johnson	Montana State University
Nebraska	Roger Gold	University of Nebraska
	Bob Wright	
Nevada	Kenneth Sakurado	University of Nevada-Reno
New Hampshire	James S. Bowman	University of New Hampshire
New Jersey	Stuart R. Race	Rutgers Univ., NJ
New Mexico	Mike English	New Mexico St. University
	Darrell Baker	NM Agric. Science Center
New York	Elson Shields	Cornell Univ., NY
North Carolina	Stephen J. Troth, Jr.	NC State University
	Jack Bacheler	
	Richard Brandenburg	
North Dakota	Dean K. McBride	ND State University
Ohio	Harold Willson/Patrick E. Lipps	Ohio State University
Oklahoma	Jim T. Criswell	Oklahoma St. University
	Stan Coppock	
	Richard C. Berberet	
Oregon	reported but not known	Oregon State University
Pennsylvania	John M. Halbrendt	
	Kenneth D. Hickey	
Rhode Island	Steven Alm	Kingston, RI
South Carolina	Jay W. Chapin	Clemson University
	Randall Griffin	
	J.W. Chapin	Edisto Exp. Station
South Dakota	Dave Walgenbach	S.D. State University
Tennessee	Darrell Hensley	University of Tennessee
Texas	Bastian Drees	Texas A&M University
	J.W. Stewart/Jesse Cocke	
Utah	Howard Deer	Utah State University
Vermont	G.B. MacCollom	University of Vermont
Virginia	D.A. Herbert	Tidewater Ag. Exp. Sta.
	Michael J. Weaver	
	Keith S. Yoder	
Washington	P.M. Phipps/Richard Maxwell	Washington St. Univ.
	Wyatt Cone	
West Virginia	John Baniecki	West Virginia University
Wisconsin	John L. Wedberg	Univsity of Wisconsin
	James B. Kotcon	
Wyoming	Mark A. Ferrell	University of Wyoming

PESTICIDE CHARACTERISTICS

MODE OF ACTION

Carbofuran is a highly toxic carbamate insecticide and nematicide. It is a cholinesterase inhibitor but is rapidly metabolized by animals into less toxic and finally non-toxic metabolites. Carbofuran is systemic in plants. It was first registered in 1969 by FMC Corporation.

FORMULATIONS

Carbofuran has been marketed in the past as a 75% wettable powder, granular and flowable formulations. It is now marketed as a flowable formulation at 4 lb. per gallon, and is 2,3,5,10 and 15 percent active ingredient granular product.

CHEMICAL PROPERTIES

The chemical name for Carbofuran is 2,3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate. Technical carbofuran is a white crystalline solid with a melting point of 153-154 C and a vapor pressure of 2,10-5 mm Hg at 33 C. The empirical formula is C12 H15 NO3 and the molecular weight is 221.3. Solubility in water is 700 ppm. Other solubilities include 30^ in N-methyl-2-pyrrolidone, 25% in dimethyl sulfoxide, 15% in acetone, 14% in acetonitrile, 12% in methylene chloride, 9% in cyclohexanone, and 4% in benzene.

TOXICOLOGICAL CHARACTERISTICS

Current available acute toxicological studies on carbofuran show the following:

- Acute oral toxicity: rat, LD50 3.8-34.5 mg/kg; mouse,

  LD50 14.4 mg/kg cat, 2.5 - 3.5 mg/kg; dog, LD50 15-18.9 mg/kg (Tox Category I)

- Acute dermal toxicity: rabbit, LD50 in isopropanol <46.4; LD50 in water >10,250; 75WP formulation LD50 in water, 3400 (Toxicity Cateogry I)

- Acute inhalation: (dust) rat. 1 hr. LD50 0.80 - 0.108 mg/L; rat 4 hr. LD50 0.075-0.108 mg/L; rat. 1 hr. LD50 >0.026 mg/L; rat, LC50 4 hr. 0.017 - 0.046 mg/L

(Toxicity Category I)

Reproductive Effects/Teratogenicity: Daily feeding of 100 ppm of carbofuran to pregnant rats greatly reduces the ability of the pups to survive. 100 ppm is similar to 1 oz. of salt on 32 tons of potato chips. Mice pups show non-fatal liver changes. The lowest amount of carbofuran that proved teratogenic to mice in the mother's diet (TDlo) was 210 ug/kg (fed throughout pregnancy).

Mutagencity: No mutagenic effects reported in animals or bacteria *using the Ames Assay). Genetic changes have been shown in algae, though.

Carcinogenicity: No such effects found reported. However, N-nitrosocarbamates are potent mutagens and carcinogens. They can be made under the acidic conditions of the stomach of some animals. Humans are possible candidates.

Organ Toxicity: No information found.

Fate in Humans and Animals: Carbofuran is poorly absorbed through the skin. It is metabolized in the liver and eventually excreted in the urine. The half-life is from 6-12 hours. About 3% of the mother's intake will be excreted in the milk. Carbofuran is highly acutely toxic to birds and a single granule may kill a small bird.

ECOLOGICAL EFFECTS

Non-target Toxicity:

Aquatic: Carbofuran may be teratogenic to frogs is very toxic to trout, Coho salmon, perch, bluegill and catfish As little as 150 ug/L of water over 96 hours will kill half of these fish.

Terrestrial: Carbofuran is very toxic to pheasants, chickens, fulvous tree ducks and Japanese quail. Red shouldered hawks have been poisoned after eating prey from carbofuran treated fields. Levels of carbofuran "naturally" occurring in Kansas fields are high enough to cause a reduct in the weight, food intake and ability to move of adult male bobwhites.

ENVIRONMENTAL FATE

Dissipation, Degradation and Persistence: The half-life of carbofuran in soils is anywhere from 30-60 days. Soil micro-

organisms are better at breaking down large amounts of carbofuran if the soil is pretreated with a small amount of carbofuran. Carbofuran is photodegradeable.

Crops: Carbofuran will not kill plants when used as directed. The halflife on crops, when applied to the roots, is about 4 days and longer than 4 days if applied to the leaves.

Water: Fire control run-off or dilution water may cause pollution of lakes and/or streams.

Air: No information found.

Metabolism (soil microbes, plants, etc.): Soil micro-organisms account for most of the breakdown of carbofuran in the soil.

Potential for Groundwater Contamination: No information found.

PRINCIPLE USES

Commodity	Total Acres	Acres Treated w/Carbofuran
Corn	62,177,000	3,927,348
Soybeans	57,550,670	50,000
Alfalfa	26,341,000	787,390 (4F)
Bananas	33,200	11,720 (5G)
Potatoes	1,247,270	12,472
Peppers	no data available	
Strawberries	40,668	5,564 (4F)
Cucurbits	158,799	65,003 (15G)
Non-bearing Peaches & Nectarines	6,642	113 (15G) 63 (4F)
Rice	2,528,330	462,741 (3G)
Peanuts	1,567,070	98,753 (15G)
Sunflowers	no data available	
Sugar Beets	1,248,070	58,398 (15G)
Tobacco	600,120	52,000 (15G/4F)
Cotton	10,131,500	70,000
Cranberries	25,430	300
Forest-Seed	-	-
Grapes	762,570	0
Sorghum	11,171,670	391,000
Sugar	775,570	49,378
Small Grains	-	-
Ornamentals	-	-

METHODOLOGY OF BENEFITS ASSESSMENT REPORT

A questionnaire was developed to assess the benefits of carbofuran (see APPENDIX 1). This questionnaire was designed to elicit key information regarding the present use of carborfuran. Each state was requested to complete a questionnaire for each crop/site for which the pesticide was used in significant quantities. Data were collected relating to the averages of production, costs, and use of carbofuran for the most current crop years. Questionnaires were mailed to each State Pesticide Liaison Representative in February 1989. Questionnaires were sent to each of the 50 states plus territories of the U.S. (Virgin Islands, Guam, Puerto Rico).

Responses were received from all 50 states, as well as the Virgin Islands; Guam and Puerto Rico. U.S. Production by commodity are given under each crop heading throughout the text.

Reporting states used a variety of methods to complete the questionnaires. In some states, all responses were formulated by a single individual working under the supervision of the State Pesticide Liaison Representative. At the other end of the spectrum, some State Liaison Representatives sent the questionnaire to extension agents and/or industry field men in key production areas. In these cases, a single individual may have responded for one or several sites. Other states fell in between these two extremes.

A computer program (See APPENDIX II) was developed by Don Tilman, University of Maryland, for tabulating economic benefits of carbofuran.

A questionnaire (See APPENDIX III) was also developed to survey state and federal agencies likely to have documentation or knowledge of wildlife mortality related to pesticides. The surveys were mailed in February 1989 to 336 individuals. Responses from 196 individuals were received.

There are three broad areas of investigation requiring specialized team expertise. These three broad areas are commodity evaluations, economic impacts, and exposure considerations. The desirable and preferred criteria for selection of assessment team members are outlined as follows. Assessment team members should have:

* Several years experience working withthe review pesticide under field conditions.

* Familiarity with the work conducted by other scientists under different climatic, soil and pest conditions; willingness to contact such persons for needed data and information.

* Knowledge of the biological performance of other compounds of non-chemical management practices for the uses in question.

* Ability to work effectively in a group environment.

* Willingness to follow a schedule and meet deadlines.

* Knowledge of pest biology, seasonal developments, production and harvesting practices and recognition of marketing practices of the commodities involved.

* Familiarity with user groups, commodity associations, and industry representatives who should be contacted for performance and economic data on actual farm usage.

* An availability for out-of-state travel to participate in assessment team meetings.

* Skills in organized and effective written and oral communication.

* Ability to provide data and background for full consideration of economic benefits to agriculture as well as the broader economic and social ramifications or consequences of use, including domestic and international concerns.

* Willingness to develop and assess regulatory options pertaining to continued registration, if such tasks are needed as the EPA Special Review proceeds.

The Carbofuran Assessment Team is represented by varied scientific disciplines and geographic areas. Team members are diverse as to their expertise concerning registered pesticide uses on various commodities, alternative control practices and the geography of these uses and practices. The members also represent various federal and state agencies.

SPECIFIC USE ANALYSES/EXPOSURE CONSIDERATIONS/CONCLUSIONS AND RECOMMENDATIONS

CORN

PART I: CURRENT REGISTERED USES FOR FURADAN 15G IN FIELD CORN, SWEET CORN, AND POPCORN

I(A). Registration Summary

Carbofuran (trade name: Furadan) is registered for control of numerous insect and nematode pests in field corn, sweet corn, and popcorn. This portion of the report will focus on Furadan 15G, the formulation most often used in corn. Most Furadan 15G used in the United States is applied to the soil at planting time to prevent several subterranean insect and nematode pests from damaging underground portions of the plants, i.e. seed, stem, and roots. Furadan 15G is also registered for foliar application to control certain aboveground insect pests that attack field corn. A postplanting application of Furadan 15G at cultivation time is registered for control of northern and western corn rootworms in field and popcorn. These three primary uses of Furadan 15G in corn are discussed in an order that corresponds with the amount of Furadan 15G applied for each use pattern, from most used to least used.

I(A.1) Planting-Time Application of Furadan 15G for Control of Soil Insects and Nematodes

Furadan 15G is registered for use as a planting-time application to (1) control northern, western, and southern corn rootworms; flea beetles; and wireworms; (2) aid in the control of white grubs and first generation European corn borers; (3) reduce losses due to stalk rot by reducing the incidence of insect wounds which permit entry by the stalk rot fungi; (4) control armyworms for approximately 4 to 6 weeks after planting; and (5) suppress cutworms. The labeled rate for these purposes is 8 ounces of product per 1,000 linear feet of row. The labeled placement for these purposes is application of Furadan 15G either in a 7-inch band ahead of the planter press wheel(s) or directly into the seed furrow.

Furadan 15G is registered for use at rates of 16 to 24 ounces of product per 1,000 linear feet of row for early season suppression of common stalk borers. The labeled placement for this purpose is exactly as stated in the preceding paragraph.

Furadan 15G is registered for use at rates of 8 to 16 ounces of product per 1,000 linear feet of row to control lesion nematodes in the northeast and midwest corn states, including Colorado and Wyoming. The labeled placement for this purpose is exactly as stated in the first paragraph.

Furadan 15G is registered for use at rates of 16 to 24 ounces of product per 1,000 linear feet of row to control first generation European corn borers. The labeled placement for this purpose is exactly as stated in the first paragraph.

Furadan 15G is registered to control (1) seedcorn maggots at a rate of 8 ounces of product per 1,000 linear feet of row; (2) southwestern corn borers (second to third generation) at rates of 12 to 24 ounces of product per 1,000 linear feet of row; and (3) southern corn billbugs (in the southeastern states) at rates of 16 to 24 ounces of product per 1,000 linear feet of row. It is also labeled at rates of 16 to 24 ounces of product per 1,000 linear feet of row to aid in the control of leafhoppers and thereby reduce losses due to maize chlorotic dwarf virus and corn stunt diseases. The labeled placement for these purposes is application of Furadan 15G directly into the seed furrow.

Furadan 15G is registered for use at rates of 12 to 16 ounces of product per 1,000 linear feet of row to control sting, stunt, stubby root, root-knot, dagger, lesion, lance, and spiral nematodes. The labeled placement for this purpose is application of Furadan 15G in a 7- to 15-inch band over the planted row.

For all of the band placements of Furadan 15G that are recommended on the label, reference is made to incorporation into the soil. For the 7-inch band placement suggested for soil insect control, the label states that Furadan 15G should be incorporated into the top 1 inch of soil by use of special covering devices or by dragging a short length of chain. For the 7- to 15-inch band placement suggested for nematode control, the label states that Furadan 15G should be incorporated into the top 3 inches of soil.

I(A.2) Foliar Application of Furadan 15G for Control of Aboveground Insects

Furadan 15G is registered for use as a foliar application at a rate of 6.7 pounds of product per acre to control southwestern and European corn borers in field corn. The label states that Furadan 15G should be applied with aircraft by broadcasting over the corn plants or with ground equipment by directing the granules into the corn whorls. This foliar application should not be made if Furadan 15G was applied at more than 8 ounces per 1,000 linear feet of row at planting time. The label also states: "Do not make more than two foliar applications per season."

I(A.3) Postplanting Application of Furadan 15G for Control of Corn Rootworms

Furadan 15G is registered for use as a postplanting application at a rate of 8 ounces of product per 1,000 linear feet of row to control northern and western corn rootworms in

field corn and popcorn. Furadan 15G should be banded over the row or side dressed on both sides of the row and then cultivated into the soil.

I(B). Hazards and Restrictions Printed on the Furadan 15G Label

Some pertinent comments about environmental hazards posed by the use of Furadan 15G and restrictions for the use of Furadan 15G appear on the current label. These comments are taken directly from the Furadan 15G label.

I(B.1) Environmental Hazards Associated with the Use of Furadan 15G

"This pesticide (Furadan 15G) is toxic to fish, birds and other wildlife. Birds feeding on treated areas may be killed. Birds killed by carbofuran pose a hazard to hawks and other birds-of-prey; bury or otherwise dispose of dead birds to prevent poisoning of other wildlife. Cover or incorporate granules in spill areas. Runoff from treated areas may be hazardous to fish in neighboring areas. Do not apply directly to water. Do not contaminate wells, wetlands or any body of water by cleaning of equipment or disposal of waste.

"**Notice:** It is a Federal offense to use any pesticide in a manner that results in death of a member of an endangered species.

"The use of Furadan 15G may pose a hazard to the following Federally designated endangered/threatened species known to be found in certain areas within the named locations.

> **Attwater's Greater Prairie Chicken**--Texas counties including: Aransas, Austin, Brazoria, Colorado, Galveston, Goliad, Harris, Refugio and Victoria
>
> **Aleutian Canada Goose**--California counties including Colusa, Merced, Stanislaus and Sutter
>
> **Kern Primrose Sphinx Moth**--Walker Basin of Kern County, California

"This product (Furadan 15G) may not be used in areas where adverse impact on the Federally designated endangered/threatened species, noted above, is likely. Prior to making applications, the user of this product must determine that no such species are located in or immediately adjacent to the area to be treated. If the user is in doubt whether or not the above named endangered species may be affected, he should contact either the regional U.S. Fish and Wildlife Service office (Endangered Species Specialist) or personnel of the State Fish and Game office.

"Carbofuran is a chemical which can travel (seep or leach)

through soil and can contaminate ground water which may be used as drinking water. Carbofuran has been found in ground water as a result of agricultural use. Users are advised not to apply carbofuran where the water table (ground water) is close to the surface and where the soils are very permeable, i.e., well-drained soils such as loamy sands. Your local agricultural agencies can provide further information on the type of soil in your area and the location of ground water."

I(B.2) Restrictions for the Use of Furadan 15G

"If prolonged intimate contact with corn and/or sorghum foliage will result, do not re- enter treated fields within 14 days of application without wearing proper protective clothing. For all other situations, do not re-enter fields less than 24 hours following application.

"Cover or incorporate granules in spill areas. Do not plant with any crop for which carbofuran treatment is not registered for at least 10 months.

"Do not rotate with any crop on soil treated at greater than 3.0 pounds active ingredient per acre for at least 10 months."

PART II: CORN PEST DAMAGE AND INFESTATION INFORMATION

None of the insects listed on the Furadan 15G label (armyworm, common stalk borer, corn rootworms, cutworms, European corn borer, flea beetles, leafhoppers, seedcorn maggot, southern corn billbug, southwestern corn borer, wireworms, and white grubs) occur at economically damaging levels during every year of production of field corn, sweet corn, and popcorn. All of these insects are occasional pests that can cause economic damage during certain years when abiotic and biotic factors are such that outbreaks occur. Some of these insects (corn rootworms, seedcorn maggot, white grubs, and wireworms) are subterranean insects, so their presence must be anticipated in advance of treatment. As a consequence, the planting-time application of Furadan 15G to prevent these insects from causing damage is usually made as "insurance" against their damage.

Estimates of losses caused by these insects have been extremely difficult to obtain for some of them and are not available nor even measurable for others. Any one of the insects is capable of causing virtually complete destruction of a given field under certain circumstances, but the percentage of annual yield loss attributable to each insect is not well documented. However, the type of crop rotation employed by a farmer is one factor that can have a dramatic impact on the potential for problems with some of the subterranean insects.

With only a few exceptions, corn rootworms are a potential

problem only in corn planted after corn. The adults (beetles) lay their eggs only in cornfields, and the larvae cannot survive on the roots of broadleaf plants such as soybeans. As a consequence, corn planted after soybeans typically does not have an infestation of corn rootworm larvae, so the use of a soil insecticide for corn rootworm control is not necessary. However, corn rootworm larvae can cause significant damage in fields where corn is grown in successive years, so the use of a soil insecticide to prevent rootworm damage is a common practice on virtually every acre of corn grown after corn.

Wireworms and white grubs are potential problems whenever a farmer plants corn into grass pasture, small grains (wheat, rye, etc.), or in any crop rotation where the previous year's crop had a significant infestation of grassy weeds. The adults of several of these species are attracted to grass hosts for oviposition, so corn planted in these fields the following year is subject to damage by these subterranean pests. Neither wireworms nor white grubs typically infest entire fields because they both have a proclivity for laying eggs in patches within a field. Certain soil types and soil conditions are more favorable for these insects' survival and development. However, without appropriate monitoring tools, locating these patches of infestation is rather difficult. As a consequence, corn planted after grass sod or small grains is usually treated with a soil insecticide at planting time.

European corn borers occur throughout most of the eastern half of the U.S., from the Rocky Mountains to the east coast, south into Louisiana, Alabama, Mississippi, and Georgia. Any one or all of the corn borers' one to four generations a year, depending on geographical location, can cause economic damage if conditions for an outbreak exist. Research and surveys over the past 30 years have determined that on an annual basis in Illinois alone, approximately 10 percent of the cornfields suffer a 9 to 15 percent reduction in yield. These estimates are based only on corn borer population surveys conducted in the fall, so yield loss estimates are for second generation borers only. The impact of the first generation of corn borers in the Corn Belt is not known. As stated previously, the yield reductions caused by insects that attack corn vary from year to year and are not well documented. In some years, yield losses can be excessive, and in other years yield losses are not measurable. It is the responsibility of the corn grower to determine the potential for damage by each of the insects discussed previously and to manage those insects in an appropriate fashion.

PART III: CORN PEST MANAGEMENT RECOMMENDATIONS

Pest management recommendations for the insects that are listed on the Furadan 15G label vary somewhat from one area of the U.S. to another, but certain generalities are common

throughout the U.S. Although the use of Furadan 15G is one management option for the insects under consideration, alternative management practices, including other insecticides and nonchemical control measures, are also addressed in this report. Within this discussion, subterranean insects and aboveground insects are addressed separately.

III(A). Subterranean Insects

Because "rescue treatments" for some subterranean insects are not effective, proper management of these pests depends on knowledge of the potential for damage. Populations of corn rootworms, white grubs, and wireworms can be estimated before the planting operation begins. This information, coupled with an understanding of the potential for insect problems in different crop rotation schemes, equips corn growers with enough knowledge to make an intelligent decision whether to use a soil insecticide, like Furadan 15G, to prevent damage to the underground portions of the corn plants.

III(A.1) Corn Rootworm Larvae

Effective management of corn rootworm larvae, the most costly insect complex to manage in corn production, begins with a thorough scouting program in July and August. Entomologists have determined that if populations of corn rootworm beetles do not exceed a certain level, larval damage the following year will not be economic. The abundance of rootworm beetles in a cornfield in July and August is an indicator of potential rootworm problems the following year. The following paragraphs are taken directly from University of Illinois Circular 899: 1990 Insect Pest Management Guide - Field and Forage Crops. Slight variations in recommended thresholds and guidelines occur among different states, but the philosophy of scouting for rootworm beetles in July and August of one year to determine the potential for rootworm problems the following year is standard.

"Corn growers should base the need for using a rootworm soil insecticide at planting on the abundance of rootworm beetles in cornfields during late summer of the previous year. Generally, if beetle numbers reached or exceeded 0.75 per plant at any time during late July, August, or September, plan to apply a rootworm soil insecticide if the field is to be replanted to corn.

"However, if the field scouted was corn following any crop other than corn, the threshold (beetles per plant) is lower. The ratio of female to male beetles in first-year corn is usually higher than in continuous corn. The females apparently migrate into first-year cornfields, so most of the beetles found there are females. As a consequence, the threshold for determining whether to rotate away from corn or to use a soil insecticide at planting may be as low as 0.5 beetle per plant.

"Fields of corn planted in late May or June of one year may have extensive rootworm damage if replanted to corn the following year. During August and September, rootworm beetles are especially attracted to late-planted or late-maturing fields. Seeking fresh pollen and silks to feed on, the beetles lay millions of eggs in these fields. Planting these fields to a crop other than corn is suggested to reduce the rootworm population.

"Farmers should seriously consider crop rotation, particularly in fields where there is a high probability of rootworm damage. Other alternatives include applications of a soil insecticide at planting or at cultivation. Planting time treatments of a soil insecticide will be the predominant method of rootworm control. However, a cultivator application in early June near the beginning of rootworm egg hatch can be an effective option. If you use a soil insecticide at planting, plan to check fields in early to mid June to determine whether damage is occurring. If so, a cultivator application may be needed as a rescue treatment.

"Crop rotation is an extremely effective way to prevent damage from northern and western corn rootworm larvae. If feasible, do not grow corn two years in succession in the same field. First-year corn following soybeans will generally not require a soil insecticide for rootworm control.

"Corn rootworm beetles deposit the vast majority of their eggs in cornfields. The larvae cannot survive on the roots of broadleaf crops (soybeans or alfalfa) or broadleaf weeds. Consequently, when a crop other than corn, soybeans for example, is planted in a field with soil containing millions of rootworm eggs, the rootworm larvae die from starvation." Throughout the U.S., rotating corn with a nonhost crop like soybeans is the primary recommendation for corn rootworm management. Where crop rotation is not feasible and farmers grow corn in the same fields in successive years, application of a soil insecticide at planting is a standard practice. Although entomologists have estimated that a 20 to 25 percent yield loss attributable to corn rootworm larvae can occur in cornfields left untreated, other evidence indicates that approximately only 1/3 of the corn acreage has an economic level of rootworm infestation every year. This suggests that soil insecticides are applied to more corn acres every year than can be economically justified. Nonetheless, soil insecticides are the primary rootworm management tool for virtually all farmers growing corn after corn.

Several soil insecticides are registered and recommended for use against corn rootworm larvae. The insecticides most widely used throughout most of the U.S. are: Aastar G (flucythrinate + phorate), Broot 15GX (thimethacarb), Counter 15G (terbufos), Dyfonate II 20G and 4E (fonofos), Furadan 15G and 4F (carbofuran), Lorsban 15G and 4E (chlorpyrifos), Mocap 15G (ethoprop), and Thimet 20G (phorate). These insecticides

represent two chemical classes: carbamates (Broot and Furadan) and organophosphorus compounds (Aastar, Counter, Dyfonate, Lorsban, Mocap, and Thimet). A pyrethroid insecticide, Force 1.5G (tefluthrin) has recently been registered for control of corn rootworm larvae.

Many of the aforementioned insecticides are registered for use at both planting and cultivation time. All are registered at equivalent rates of 1 pound of active ingredient per acre based on 40 inch row spacing (6 and 8 ounces of product per 1,000 linear feet of row for 20G and 15G formulations, respectively). The exception is Force, which is registered at rates of 0.1 to 0.125 pound of active ingredient per acre (8 to 10 ounces of product per 1,000 linear feet of row).

Because evidence exists that the continuous use of some soil insecticides, specifically Broot, Dyfonate, and Furadan, can eventually lead to a reduction in efficacy, many states currently recommend that farmers should not use the same insecticide for several consecutive years. Within many of these recommendations, suggestions about alternating among chemical classes appear. For this reason, the availability of more than one class of soil insecticides helps fend off potential problems related to the development of insect resistance or the development of enhanced microbial degradation.

Currently the only other potential alternative for management of corn rootworm populations is the aerial application of an insecticide to prevent rootworm beetles from laying eggs. This alternative requires very specific knowledge, intensive field scouting, and commitment to the program. It is not generally practiced by most corn growers in the U.S., but some growers in the midwestern states have adopted this practice to reduce the potential for rootworm problems. Unfortunately, many of these growers also apply an insecticide at planting. The use of both of these management tools in the same field is strongly discouraged by most entomologists.

III(A.2) Seedcorn Maggots, White Grubs, and Wireworms

Seedcorn maggots, white grubs, and wireworms can be controlled effectively with soil insecticides, but the incidence of occurrence of these pests is relatively low. Consequently, except under specific circumstances, the application of soil insecticides as "insurance" to prevent damage by these insects is not recommended by most entomologists. Exceptions occur when corn is planted into grass sod or when the farmer has determined that the pest(s) is/are present in his fields. Detecting the presence of wireworms can be accomplished with a baiting program, a specialized scouting procedure that detects wireworms a few weeks before planting begins. Detecting the presence of white grubs is much more difficult. Only by finding and identifying white grubs that have been uncovered during tillage operations

can a grower determine whether he needs a soil insecticide to prevent their damage.

Both seedcorn maggots and wireworms can be managed with the use of seed treatment formulations of some insecticides, specifically diazinon or diazinon + lindane. Although the seed treatment will protect the seed against attack by wireworms, it will not protect the underground portion of the stem. Consequently, farmers should use a soil insecticide if they encounter large infestations of wireworms. The use of a soil insecticide applied at planting is rarely justified for seedcorn maggot control.

Soil insecticides registered for control of seedcorn maggots, white grubs, or wireworms include Aastar G (phorate + flucythrinate), Counter 15G (terbufos), Dyfonate II 20G and 4E (fonofos), Force 1.5G (tefluthrin), Furadan 15G and 4F (carbofuran), Lorsban 15G and 4E (chlorpyrifos), Mocap 15G (ethoprop), and Thimet 20G (phorate). However, not all of these insecticides are registered for control of all three insects, and the recommended application rates and placements are not the same for all three insects. For example, Furadan 15G is registered for control of seedcorn maggots at 8 ounces of product per 1,000 linear feet of row applied in furrow at planting. Furadan 15G is labeled to "aid in the control" of white grubs, and it is labeled for either band or furrow placement for control of wireworms. Lorsban 15G is labeled for control of all three insects, but recommended placements and rates vary among the insects: in furrow application of 8 ounces of product per 1,000 linear feet of row for seedcorn maggots; in furrow application of 8 to 16 ounces of product per 1,000 linear feet of row for white grubs; and band or furrow application of 16 ounces of product per 1,000 linear feet of row for wireworms.

III(A.3) Cutworms

Except under rather specific circumstances (certain cutworm species that overwinter and certain no-till conditions), the use of a soil insecticide to prevent damage by cutworms is discouraged by most entomologists in the U.S. Cutworm infestations are very difficult to predict, so planting time insecticides are often applied to fields in which economic levels of cutworms do not develop. Several insecticides are registered for control of cutworms after cutworms exceed certain established economic thresholds. These postemergence treatments are usually quite effective and are often cheaper than planting time applications of granular insecticides. In addition, the application of postemergence insecticides is usually based on need, whereas application of insecticides at planting time are strictly "insurance" treatments.

The following comments are taken directly from University of Illinois Circular 899: 1990 Insect Pest Management Guide - Field and Forage Crops. Slight variations in recommended thresholds

and guidelines occur among different states, but the philosophy of scouting for cutworms and their damage before making a management decision is standard.

"Because of the uncertainty in predicting which fields will have light, moderate, or heavy infestations of cutworms, it is advisable to use rescue treatments for cutworm outbreaks rather than to use a preplant or planting time treatment unnecessarily. Based on the relatively low incidence of cutworm problems over the past 30 years, a grower should find an economic advantage to the wait-and-see system, which involves field scouting rather than a costly always-apply program in which the soil insecticide is routinely applied at or before planting for a problem that may not exist."

Insecticides registered for prevention of cutworms in corn include: Aastar G (phorate + flucythrinate), Counter 15G (terbufos), Dyfonate II 20G (fonofos), Force 1.5G (tefluthrin), Furadan 15G (carbofuran), Lorsban 15G (chlorpyrifos), Mocap 15G (ethoprop), and Pounce 1.5G (permethrin) as planting-time applications; Ambush 2E and 25W (permethrin), Asana XL (esfenvalerate), Lorsban 4E (chlorpyrifos), Pounce 1.5G and 3.2EC (permethrin), and Pydrin 2.4EC (fenvalerate) as pre-emergent applications; and Lorsban 4E (chlorpyrifos) as a broadcast preplant incorporated application. Insecticides registered for postemergence rescue treatments when cutworms exceed economic levels, the preferred management approach, include Ambush 2E and 25W (permethrin), Asana XL (esfenvalerate), Lorsban 4E (chlorpyrifos), Pounce 3.2EC (permethrin), and Pydrin 2.4EC (fenvalerate).

III(B). Aboveground Insects

Furadan 15G is registered for control of several insects that attack the aboveground portions of corn plants: armyworm, common stalk borer, European corn borer, flea beetles, leafhoppers, southern corn billbug, and southwestern corn borer. However, the Furadan 15G label lists two different application methods for control of some of these pests: planting time and foliar applications. These two methods of application are addressed separately.

III(B.1) Planting Time Application of Furadan 15G to Control Aboveground Insects

Furadan 15G is registered as a planting time application to control, aid in control, or suppress armyworms, common stalk borers, European corn borers, flea beetles, leafhoppers, southern corn billbugs, and southwestern corn borers. However, more efficient and effective control of these insects is achieved by the use of foliar applied insecticides after the insect populations exceed established economic thresholds. Except in rare instances, the use of Furadan 15G at planting time to

prevent damage by the aforementioned pests is not recommended by entomologists throughout the U.S. Most of these insects can be rather easily monitored, so management suggestions include field scouting followed by the use of insecticides only when necessary.

III(B.2) Foliar Application of Furadan 15G

Furadan 15G is registered as a foliar application to control economic infestations of European corn borers and southwestern corn borers. Both insects can cause significant damage to corn in certain areas of the U.S., and they are considered to be key pests of corn. Management recommendations for both insects include timely field scouting, the use of established economic thresholds, and application of an insecticide if the population exceeds those thresholds. The insecticides most widely used throughout most of the U.S. are: Ambush 2E and 25W (permethrin), Asana XL (esfenvalerate), Dipel 10G and ES (Bacillus thuringiensis), Dyfonate II 20G (fonofos), Furadan 15G and 4F (carbofuran), Lorsban 15G and 4E (chlorpyrifos), Penncap-M (encapsulated methyl parathion), Pounce 3.2EC and 1.5G (permethrin), and Pydrin 2.4EC (fenvalerate).

Other management alternatives for these two pests include destruction of corn residue and planting varieties resistant to the insects. However, neither of these management techniques is effective enough or practiced widely enough to prevent the insects from reaching economic levels during some years. As a consequence, scouting programs are strongly encouraged, and the use of effective insecticides is recommended only when economic thresholds have been exceeded.

PART IV. SUMMARY OF RESPONSES TO QUESTIONNAIRES

IV(A). Survey Techniques (Table 1, APPENDIX 4)

A survey form, instructions, and a list of questions that required narrative responses were sent to 53 states and U.S. territories. We requested information about the use of Furadan and alternatives on corn (field, pop, and sweet) in each state and territory surveyed. The types of information for which we requested responses on the survey form were as follows:

1. Target pest(s)

2. Years for which data were submitted (requested averages of 1984-1987)

3. Acreage of crop planted

4. Production unit (bushels or pounds)

5. Unit yield per acre

6. Price per unit

7. A listing of chemical and nonchemical alternatives

8. Percentage of total acreage currently treated with carbofuran and the different alternatives

9. Percentage of total acreage that would be treated with the different alternatives if carbofuran were withdrawn

10. Treatment rate (pounds of active ingredient per acre)

11. Method(s) of application

12. Cost for treatment ($ per acre), including application cost

13. Average number of treatments needed to control the target pest(s)

14. Effect on yield of crop if carbofuran were withdrawn and alternatives were used

15. Effect on quality of crop if carbofuran were withdrawn and alternatives were used

The questions that required narrative responses were asked to obtain information about environmental and applicator safety concerns in reference to the use of carbofuran. These questions are listed and discussed in Part VIII of this report.

IV(B). Summary of Responses to the Survey Forms

A summary of responses to the survey forms is presented in Table 1. Of the 53 surveys sent to states and U.S. territories, we received responses from 45. Those not responding were Connecticut, Delaware, Massachusetts, New Mexico, Pennsylvania, Puerto Rico, Virginia, and Washington. Of the 45 responses, eight states and territories (Alaska, California, Guam, Hawaii, Maine, Nevada, Oregon, and the Virgin Islands) reported no appreciable use of Furadan on corn. Of the remaining 37 responses, eight responses either lacked appropriate data for analysis or included data that could not be interpreted. These responses were submitted by Arizona, Montana, Rhode Island, Tennessee, Texas, Vermont, West Virginia, and Wyoming, and they represented 2,959,400 acres of field corn. Of the remaining 29 responses, two responses included data for uses of corn other than grain: Idaho for sweet corn seed and popcorn seed production, and New Hampshire for corn silage production.

The remaining responses contained at least some data that could

be used for economic analyses (Table 2). Eighteen states submitted a complete set of data regarding the use of Furadan 15G and alternatives to control the soil insect pest complex in field corn. Two states (Louisiana and Mississippi) submitted data about the use of Furadan 15G to control the soil insect complex in field corn, but the responses did not include a list of alternatives. Seven states submitted a complete set of data regarding the use of Furadan 15G and alternatives to control European corn borers in field corn. Five states submitted data about the use of Furadan 15G to control both the soil insect complex and European corn borers in field corn. Three states submitted a complete set of data regarding the use of Furadan 15G and alternatives to control nematodes in field corn. One state submitted a complete set of data regarding the use of Furadan 15G to control both the soil insect complex and nematodes in field corn.

A total of 36 survey forms (34 with a complete set of data) were used to calculate the economic data discussed in Part VII of this report. The summaries of the survey forms for each state/target pest combination are presented in Appendices A-D. These responses represent an estimated 68,386,500 acres of field corn grown in the U.S.

Four states (Florida, Missouri, New York, and North Carolina) submitted data regarding the use of Furadan 15G to control the soil insect complex and nematodes in sweet corn. The responses represented 91,870 acres of sweet corn grown in the U.S.

Only one state (Missouri) submitted data regarding the use of Furadan 15G to control the soil insect complex in popcorn. One other state (New York) submitted data regarding the use of Furadan 15G on both popcorn and field corn combined.

PART V. FURADAN USE DATA AND CROPPING PRACTICES

V(A). On-farm Use Data

The percentages of acres and total acres of field corn currently treated with carbofuran and chemical alternatives for control of different target pests are presented in tables 3 - 6 (Table 3, soil insects; Table 4, European corn borer; Table 5, nematodes; and Table 6, a combination of pests). The percentages of acres and total acres that currently are not treated with chemical insecticides are presented in Table 7. The data in these tables represent only the states that responded with a complete set of information for the respective pests. Extrapolations were not made for those states that did not respond nor for those states that responded with incomplete or confusing data.

Although we requested average data for the use of granular insecticides during the years 1984-87, some states submitted data for other years. However, no data were older than 1984. Most states that were surveyed indicated that the percentage of acres treated with carbofuran over the past several years has declined, sometimes rather significantly. In general, the percentage of acres treated with carbofuran was higher in the southern and western states.

An estimated total of 2,350,019 acres of field corn in 20 states were treated annually with carbofuran for control of the soil insect complex (Table 3). Only five states reported that the percentage of field corn acres treated with carbofuran for control of the soil insect complex exceeded 10% (Arkansas - 65%; Louisiana - 50%; Mississippi - 25%; North Carolina - 17%; and Oklahoma - 25%). Most of the Corn Belt states reported that carbofuran use for control of the soil insect complex in field corn was less than 10%.

An estimated total of 15,876,758 acres of field corn in 18 states were treated annually with chemicals other than carbofuran (i.e., other granular insecticides) for control of the soil insect complex. Of the estimated 18,226,777 acres of field corn in 20 states treated annually with a soil insecticide to control the soil insect complex, an estimated 13% was treated annually with carbofuran.

Of the seven states responding specifically to the request for insecticide use data regarding the control of European corn borers, none reported carbofuran use on more than 7% of the acres of field corn (Table 4). An estimated total of 652,038 acres of field corn in seven states were treated annually with carbofuran for control of European corn borers. An estimated total of 1,156,000 acres of field corn in six states were treated annually with chemicals other than carbofuran for control of European corn borers. Of the estimated 1,808,038 acres of field corn in seven states treated annually with an insecticide to control European corn borers, an estimated 36% was treated annually with carbofuran.

Because only three states responded specifically to the request for insecticide use data regarding the control of nematodes in field corn, the data are probably not sufficient to warrant further analysis. In fact, because carbofuran applied for control of nematodes in corn is applied in the same manner and at the same time as it is for control of soil insects, the data in Table 5 are probably confounded, or even included, with the data in Table 3.

Six states responded to the request for insecticide use data in field corn without designating different species of pests. One response (Florida) included data combined for both insects and nematodes, and the other five responses included data combined

for both soil insects and European corn borers. From these responses, an estimated total of 925,291 acres of field corn in six states were treated annually with carbofuran for control of a combination of pests (Table 6). An estimated total of 6,638,159 acres of field corn in six states were treated annually with chemicals other than carbofuran for control of a combination of pests. Of the estimated 7,563,450 acres of field corn in six states treated annually with an insecticide to control a combination of pests, an estimated 12% was treated annually with carbofuran.

Overall, an estimated total of 27,598,265 acres of field corn in 26 states were treated annually for control of soil insects, European corn borers, and nematodes. Of this total, 3,927,348 acres (14%) were treated annually with carbofuran. Because the soil insect/nematode complex is treated at a different time of the growing season than European corn borers, the estimated totals do not necessarily represent separate acreages. In other words, certain acres treated for control of the soil insect/nematode complex may also be treated for European corn borers.

An estimated total of 34,046,026 acres of field corn in 19 states were not treated annually with soil insecticides to control the soil insect complex. In the seven states that reported specifically on European corn borers, an estimated total of 30,315,713 acres of field corn were not treated annually with an insecticide. In the six states that reported on a combination of insects and nematodes, an estimated total of 8,025,050 acres of field corn were not treated annually with an insecticide. (All data taken from Table 7.)

V(B). Frequency of Application, Number of Applications, and Active Ingredient Applied Per Acre

Most states that responded to the survey indicated that the average frequency of application of soil insecticides to field corn to control soil insects and nematodes was one per season. Most states indicated that the average frequency of application of insecticides to control European corn borers was also one per season. However, a few states indicated that as many as two or three applications of insecticides are necessary to control second or third generation European corn borers. In general, a maximum of two applications per season would be made on some acres of field corn to control both the soil insect complex and European corn borers.

On the average, 1 pound of active carbofuran per acre, based on 40-inch row spacing, is applied to control the soil insect complex in field corn. The rate of application is the same for all of the other common soil insecticides, with the exception of Force 1.5G, which is usually applied at 0.1 pound of active ingredient per acre. However, this relatively new compound has

not been widely used.

On the average, 1 pound of active carbofuran per acre is applied to control European corn borers in field corn. The rate of application is generally the same for the organophosphorus insecticides, but the rate is 0.1 to 0.2 pound of active ingredient per acre for the pyrethroids (Ambush, Asana, Pounce, and Pydrin).

On the average, 2 pounds of active carbofuran per acre are applied to control nematodes in field corn. The rate of application is 1 to 2 pounds of active ingredient per acre for the other soil insecticides.

V(C). Cropping Practices

For control of the soil insect and nematode complex in field corn, applications of soil insecticides are usually made at planting time. On a small percentage of acreage, soil insecticides are applied at cultivation time to control corn rootworm larvae when the plants are in the 3- to 5-leaf stages (V3-V5). Applications of insecticides to control first generation European corn borers are typically made when corn is in the whorl stage (V7- V9), and applications of insecticides to control second generation European corn borers are typically made during pollination or shortly after the completion of pollination when the ear is beginning to fill out (R1-R2 stages).

Planting-time application of Furadan 15G is usually made with insecticide application boxes mounted directly on the corn planter. The insecticide is metered out into a 7-inch band over the planted row or directly into the seed furrow. Furadan 15G intended to control European corn borers is most often broadcast over a field by a fixed-wing aircraft or a helicopter. However, some acreage of field corn is treated with Furadan 15G applied by ground equipment that directs the granules over the whorls of the corn plants.

In general, most of the field corn that is treated with insecticides for control of the soil insect/nematode complex and/or European corn borers is bordered by other field crops, i.e., corn, soybeans, wheat, alfalfa, etc. However, treated cornfields may also be adjacent to residential areas, rivers, streams, ponds, etc. Warnings about the potential hazards of runoff or drift into nontarget areas appear on all insecticide labels.

Soil insecticides, including Furadan 15G, are typically recommended for use only on fields of corn that have an identifiable potential soil insect problem. Most of the acres of field corn that are treated with a soil insecticide in the Corn Belt are treated for corn rootworm control in corn planted after corn. Corn planted after soybeans typically does not need a

preventive soil insecticide treatment. However, fields of corn planted after grass sod, set- aside acres, or wheat may also receive an insecticide at planting time. Exceptions to these crop rotation guidelines exist primarily in the southern U.S. where soil insect problems occur more frequently. There is no relationship between crop rotation and the incidence of European corn borer infestations.

Insecticides, including Furadan 15G, are recommended by entomologists throughout the U.S. only when a need is identified. Preventive planting-time insecticides can be integrated into a good crop management system if scouting programs reveal the potential for a soil insect problem. The use of soil insecticides as "insurance" just in case an insect problem develops is strongly discouraged.

PART VI: POTENTIAL FOR PEST RESISTANCE

The potential for the development of resistance to insecticides within a pest population always exists when that pest population is treated with insecticides on a recurring basis. Western and northern corn rootworms developed resistance to the cyclodiene insecticides after these insecticides had been used for several years on many acres of corn. Cyclodiene insecticides like aldrin and heptachlor were often broadcast over many acres of field corn. Because of the persistent properties of these insecticides and the broadcast application techniques, corn rootworm larvae were exposed to the chemicals for extended periods of time. As a consequence, the rootworms developed resistance to such an extent that the cyclodiene insecticides became ineffective for protecting corn root systems from attack by the larvae.

Currently used soil insecticides are either organophosphorus compounds, like terbufos (Counter) and chlorpyrifos (Lorsban), or carbamates, like carbofuran (Furadan) and trimethacarb (Broot). These compounds are not as persistent as the cyclodienes, and modern insecticides are applied either in a 7-inch band over the row or directly into the seed furrow. As a consequence, corn rootworm larvae are not exposed to organophosphates or carbamates in the same manner or for as long as they were exposed to the cyclodienes. These two characteristics alone suggest that the potential for development of rootworm resistance to modern soil insecticides is lower or would take a considerably longer time to develop. In addition, fewer acres of field corn are currently treated with soil insecticides than were treated with cyclodienes in the past, and corn rootworm beetles are quite mobile, moving readily from field to field. Overall, corn rootworms are much less exposed to soil insecticides now than they were in the past.

Nevertheless, continuous corn receives a soil insecticide treatment virtually every year, so rootworms that are present in

these cropping schemes are exposed to soil insecticides every year. One management technique that can slow down the onset of resistance in a pest population is the alternation of insecticides among different classes of chemistry, for example, alternating between organophosphates and carbamates. The most recently registered soil insecticide, tefluthrin (Force), introduces the pyrethroid class as yet a third class of chemistry among the soil insecticides.

Entomologists in many Corn Belt states currently suggest that a corn producer should consider alternating among the classes of soil insecticides to slow down or circumvent the development of insecticide resistance within the rootworm population. The loss of an entire class of chemistry in the soil insecticide market would eliminate part of the insecticide- rotation management scheme. Although trimethacarb (Broot) is also a carbamate, its use throughout the U.S. is extremely low. Carbofuran (Furadan) is the only other carbamate soil insecticide used on an appreciable number of acres. The loss of carbofuran would create a greater potential for the onset of resistance to the organophosphates within corn rootworm populations, particularly if most corn acres currently treated with carbofuran are subsequently treated with organophosphates, rather than the pyrethroid Force.

PART VII: ECONOMIC AND SOCIAL IMPACTS

VII(A). Methodology, Data, and Quantitative Use Analysis of Carbofuran and Alternatives

The data that were used to determine the potential economic impacts that would ensue if Furadan 15G were withdrawn were compiled from the responses to the survey discussed in Part IV of this report. Tables 8-10 present summaries of these economic analyses in the form of potential changes in net return per acre and potential changes in net return for the state in question if carbofuran were withdrawn and alternative chemicals were used.

The analyses were conducted in the following manner. For each state/target pest combination, the percentage of field corn acres that were treated annually with carbofuran (average from 1984-87) was taken directly from the survey form. To determine the total cost of carbofuran treatment for the state and target pest in question, the average cost per acre for carbofuran treatment was multiplied by the number of acres treated with carbofuran. The percentages of total acres that would be treated with each of the different chemical alternatives if carbofuran were withdrawn were also taken directly from the survey form. Only those chemical alternatives that would be used to treat acres formerly treated with carbofuran were analyzed. To determine the total cost of switching to the alternatives, the average costs per acre for

each of the chemical alternatives were multiplied by the number of acres that would be treated with each of the chemical alternatives. The change in production cost (per acre) was calculated by subtracting the total cost of switching to the chemical alternatives from the total cost of carbofuran treatment. If the cost of switching from carbofuran to the alternatives was less than the cost of treating with carbofuran, the change in production cost is represented by a negative number, i.e., the cost of switching to alternatives is cheaper. If the cost of switching from carbofuran to the alternatives was higher than the cost of treating with carbofuran, the change in production cost is represented by a positive number, i.e., the cost of switching to alternatives is more expensive.

The effect on the yield (bushels per acre) of field corn if carbofuran were withdrawn and alternatives were used was taken directly from the survey form. The effect on economic return of the yield of field corn was determined by multiplying the change in crop yield (bushels per acre) by the average price per bushel. The overall change in net return (per acre) was determined by adding or subtracting the values for the effect on economic return and the change in production cost. For example, an overall decrease in net return (a negative value) would be the consequence of an increase in production cost plus a decrease in economic return of crop yield if alternatives were used. An overall increase in net return (a positive value) would be the consequence of a decrease in production cost plus an increase in economic return of crop yield if alternatives were used. Depending on which value (change in production cost or change in economic return) was larger, a decrease in production cost coupled with a decrease in economic return of crop yield could result in either a decrease or an increase in overall net return.

The values for overall change in net return (per acre) if carbofuran were withdrawn and alternatives were used are presented for each state/target pest combination in Table 8 (soil insect complex), Table 9 (European corn borers), and Table 10 (pest combinations). Because only three states responded specifically to the request for insecticide use data regarding control of nematodes in field corn, the data were not sufficient to warrant economic analysis. In fact, because carbofuran applied for control of nematodes in corn is applied in the same manner and at the same time as it is for control of soil insects, the data for control of nematodes are probably confounded, or even included, with the data for control of the soil insect complex.

In tables 8-10, the net return for the state in question was calculated by multiplying the acres treated annually with carbofuran by the overall change in net return if carbofuran were withdrawn and alternatives were used on the acres treated with carbofuran. A negative value represents a loss in net return for

the state, and a positive value represents a gain in net return for the state if carbofuran were withdrawn and alternatives were used on the acres treated with carbofuran.

VII(B). Comparative Cost-Effectiveness of Carbofuran and Alternatives

Comparisons of costs and effectiveness of carbofuran versus the chemical alternatives for control of soil insects in field corn are summarized in Table 8. The analyses revealed that 7 of 18 states would experience a negative net return, 3 states would experience no change in net return, and 8 states would experience a positive net return if carbofuran were withdrawn and alternatives were used. The overall change in net return for the 18 states for which data were analyzed was + $1,864,491. The positive net returns were calculated most frequently for the Corn Belt states. Individuals supplying information for Indiana, Iowa, Kansas, Michigan, and Minnesota indicated that, in general, the chemical alternatives were cheaper and the economic return of corn yield would not change or would increase if carbofuran were withdrawn and alternatives were used. The negative changes in net return for three Corn Belt states (Illinois, - $16,000; Kentucky, - $11,360; North Dakota, - $5,883) were rather insignificant, all three states indicating that switching from carbofuran to chemical alternatives would be slightly more expensive in terms of production costs but would involve no change in economic return of crop yield. The positive net return for Missouri (+ $13,243) can be attributed to a slight reduction in production costs and no change in economic return of crop yield if carbofuran were withdrawn and alternatives were used. The most significant negative changes in net return if carbofuran were withdrawn and alternatives were used were reported from southern and western states (Arkansas, North Carolina, Oklahoma, and Utah). Except for Utah and Oklahoma, the primary soil insect pests were insects other than corn rootworms, for which carbofuran was rated as a more effective product than the chemical alternatives.

Of the seven states reporting specifically on costs and effectiveness of carbofuran and chemical alternatives for control of European corn borers, Missouri did not supply enough information for appropriate economic analysis. Therefore, the results from only six states are presented in Table 9. Colorado reported no change in net return if carbofuran were withdrawn and alternatives were used; Kansas and South Dakota reported a positive change in net return if carbofuran were withdrawn and alternatives were used; and Illinois, Iowa, and North Carolina reported a negative change in net return if carbofuran were withdrawn and alternatives were used. The overall change in net return for these six states was - $1,993,445, indicating that, in general, carbofuran is a more effective product than the alternatives for control of European corn borers and that the economic return of crop yield would decrease if carbofuran were

withdrawn and alternatives were used.

Comparisons of costs and effectiveness of carbofuran versus the chemical alternatives for control of a combination of pests in field corn are summarized in Table 10. South Carolina reported no change in net return if carbofuran were withdrawn and alternatives were used; Florida and Maryland reported a negative change in net return if carbofuran were withdrawn and alternatives were used; and Nebraska, Ohio, and Wisconsin reported a positive change in net return if carbofuran were withdrawn and alternatives were used. The overall change in net return for these six states was - $815,876. This total was influenced primarily by the very large decrease (- $24.67 per acre) in net return, reported by Florida, if carbofuran were withdrawn and alternatives were used. The Florida data reflect that higher rates are used for nematode control in field corn; alternatives are considerably less effective and more expensive than carbofuran; and some acres currently being treated with carbofuran would receive no treatment, and therefore produce considerably lower yields, if carbofuran were withdrawn.

For the 30 different responses that could be analyzed appropriately for state/target pest combinations, the overall net return if carbofuran were withdrawn and alternatives were used was - $944,830 (sum of net returns for the states presented in tables 8-10). This figure does not include analyses of data from six different states for which the data were incomplete.

VII(C). Impacts of Non-Use of Carbofuran and Alternatives

The data that were submitted regarding the potential impact of cancellation of carbofuran and subsequent non-use of the chemical alternatives were far from complete. The states that provided information about the potential average yield loss if acres currently being treated for soil insects were not treated with an insecticide were Colorado (20%), Georgia (20%), Illinois (12.5%), Iowa (7%), Kansas (10%), and Minnesota (5%) (Appendix A). The potential average yield loss for these six states was 12.4% of an estimated 11,494,699 acres of field corn currently being treated with soil insecticides for control of soil insects. This represents a potential yield loss of 134,725,428 bushels of corn at an average price of $2.18 per bushel, or a potential economic loss of $293,701,433 for the six reporting states.

The states that provided information about the potential average yield loss if acres currently being treated for European corn borers were not treated with an insecticide were Colorado (18.75%), Illinois (10%), Iowa (10%), and Kansas (3%) (Appendix B). The potential average yield loss for these four states was 10.4% of an estimated 1,267,038 acres currently being treated with insecticides for control of European corn borers. This

represents a potential yield loss of 15,390,505 bushels of corn at an average price of $2.25 per bushel, or a potential economic loss of $34,628,636 for the four reporting states.

The states that provided information about the potential average yield loss if acres currently being treated for a combination of pests were not treated with an insecticide were Florida (50%), Ohio (9%), and South Carolina (10%) (Appendix D). The potential average yield loss for these three states was 23% of an estimated 1,824,200 acres currently being treated with insecticides for control of a combination of pests. This represents a potential yield loss of 22,654,750 bushels of corn at an average price of $2.25 per bushel, or a potential economic loss of $50,973,188 for the three reporting states.

From 13 separate reports regarding the use of insecticides to control the soil insect complex, European corn borers, and a combination of pests in field corn, the estimated potential economic loss of not using insecticides is $379,303,257. Combined with this loss figure are estimates of quality loss if neither carbofuran nor the alternative insecticides are used to control the pests. Estimates of quality losses were provided by Mississippi (soil insects, 2%), Missouri (European corn borers, 2%), Florida (combination of pests, 50%), and Nebraska (combination of pests, 10%). Economic analyses were not conducted for quality loss data for field corn.

PART VIII: EXPOSURE CONSIDERATIONS (BIOLOGICAL EFFECTS)

In addition to the pesticide use survey form, the corn subcommittee developed a questionnaire with the objective of obtaining information about environmental and applicator safety concerns in reference to the use of carbofuran and other insecticides. The questions required narrative responses. Responses to the seven questions were submitted from 36 states. The seven questions and corresponding summary of responses are provided in this section of the report.

1. Are there any environmental reasons that would deter you from recommending carbofuran? If yes, please list the most important reasons.

There were 20 unqualified "No" responses and 5 qualified "No" responses to this question. Typical of the five qualified "No" responses was "There are no more concerns for Furadan use than for the use of all other corn soil insecticides, if insecticides are applied properly at labeled rates, and according to guidelines and directions on the labels." Environmental concerns that were addressed by some respondents included ground water contamination with Furadan and the effect of Furadan on nontarget organisms. Ground water contamination appeared as a concern in 7 responses. A typical response was, "Furadan can leach or seep

into ground water, and users are advised not to apply Furadan where water tables are close to the soil surface and where soils are very permeable." Other respondents expressed concerns about application of Furadan to sloping lands next to bodies of water. Furadan solubility and soil permeability, as they relate to ground water contamination, were concerns expressed by several respondents.

Concerns about the effect of Furadan on nontarget organisms were avian toxicity (3 responses) and earthworm toxicity (2 responses). One respondent indicated that "Furadan is safer on insect predators and has a minimal effect on mite resurgence. Furadan does not destroy the early season prey base of aphids, and, therefore, more predators inhabit these fields (vs. fields treated with Counter or other systemics)."

One respondent expressed concern about the flow of insecticide granules that continues when the planting units are raised out of the ground. He added that in-furrow applications should be recommended for reduced and no-tillage systems, and foliar applications for European corn borers are risky.

2. What are two or more major reasons (other than cost) that you would recommend Furadan granules rather than other chemicals for corn pest control?

Responses to this question fell into three major categories: better efficacy, availability of an alternative chemical class, and improved applicator safety.

Improved efficacy and the systemic action of Furadan were the reasons given by 18 respondents for recommending Furadan granules rather than other chemicals for corn pest control. European corn borer, sugarcane beetle, fall armyworm, chinch bugs, corn rootworm, billbug, and flea beetles were insects for which respondents indicated that Furadan was more effective than other insecticides. Some respondents indicated that Furadan has slightly better nematicidal properties than other granular insecticide/nematicides and that it seems more efficacious for endoparasitic nematodes. Some respondents categorically stated that Furadan is effective, provides consistent control with a single application, and is widely available. One respondent indicated that Furadan is effective on organic soils where most other soil insecticides are not. One respondent stated that Furadan is the only granular insecticide that is very effective against the common stalk borer.

Furadan being in a different class of chemistry (carbamate) than other soil insecticides (organophosphates) was another reason that 7 respondents would recommend Furadan granules rather than other chemicals for corn pest control. Reasons expressed for the importance of availability of an alternative class of chemistry included: previous control problems with organophosphate

insecticides; situations where enhanced biodegradation has been verified; alternating chemical classes (carbamates to organophosphates) for resistance management of pests with low mobility; and organophosphate resistance management.

In regard to safety, Furadan was characterized as being easy to handle with smooth flow characteristics and very little dust when compared with other granular soil insecticides.

Other responses to this question were that Furadan can be used in-furrow and in no-till systems and that there is no drift when Furadan is applied by air.

"None" was the response provided by 6 different individuals.

3. Are there any special or localized situations in your state where you recommend Furadan because of its unique role as a planting time systemic treatment for pests such as chinch bugs, flea beetles, billbugs, etc.? If yes, explain briefly and list the alternatives.

There were 19 responses of "No" or "None" to this question.

Among the "Yes" responses, some listed insects such as chinch bugs, sugarcane beetles, European corn borers, and flea beetles (transmission of Stewart's bacterial wilt (SBW) disease), but they discussed no alternative chemicals. Other respondents listed flea beetle control (to prevent SBW) in seed corn production fields as a special situation where Furadan would be recommended; alternatives included Counter (less effective), esfenvalerate, permethrin, chlorpyrifos, and carbaryl. Another respondent listed chinch bugs as an insect for which Furadan would be especially recommended, with Counter and Dyfonate listed as alternative chemicals (there are no cultural control alternatives). A third respondent indicated that billbugs feeding on corn grown on organic soils would require Furadan, and the alternatives are Counter or Lorsban, depending on soil type. Common stalk borer was listed as another insect for which Furadan would provide control through its systemic activity, and Pydrin and Ambush were listed as alternatives.

One respondent stated that preventive treatments (no pests listed) of Lorsban and Sevin are alternatives to the application of Furadan. One response indicated that Furadan is the alternative in situations where organophosphates (not listed) have become ineffective or less effective (no pests listed).

4. Are you aware of any bird or other wildlife kills caused by the use of granular insecticides or nematicides in your state? If yes, please list the number of incidents, species involved and the cause.

There were 24 responses of "No" or "None". Other responses were:

"Hearsay only," "Ducks" (New York), "I have seen 3 dead birds in corn fields since 1972" (North Carolina), and "Kills will occur with uncovered granules, but no kills have been observed."

5. Are there any changes in application (rate, timing, placement, etc.) of granular insecticides or nematicides that would reduce or alleviate problems associated with birds or other wildlife? If yes, please list.

The majority of concern (10 responses) about Furadan use centered around granules that are not incorporated or covered by soil, primarily at row ends. As a consequence, respondents provided suggestions that would help solve this problem: "Cover granules at row-end turns," "Change color of granules to reduce bird attraction," "Reduce application rates," "Early shut-off of equipment at row-ends," and "Avoid spills and develop electronic shut-off (vs. wheel driven) for granular applicator equipment." A total of 17 respondents indicated that complete incorporation (9) of granules or in-furrow placement (8) would reduce or alleviate problems associated with birds or other wildlife contacting Furadan granules left uncovered on the soil surface.

Two respondents indicated that broadcast application of Furadan is the greatest risk, and one of them suggested its elimination.

Timing of applications of Furadan to correspond to the fewest number of birds present in cornfields was suggested by one respondent. One other respondent suggested the use of a bird repellent in conjunction with Furadan applications.

6. What granular insecticide or nematicide do you most frequently recommend for corn pest control, and why?

The following chemicals were listed with the frequency of response indicated in parenthesis: Counter (15), Diazinon (1), Dyfonate (3), Furadan (15), Force (1), Lorsban (6), and Thimet (3).

Efficacy was the most commonly given reason (7 responses) for recommending Furadan. One respondent indicated that Thimet is equally effective and costs less, and another stated that all granular insecticides perform equally.

Five respondents indicated that recommendations for the use of various insecticides depend on specific factors including pest, placement, costs, field history, safety, etc. In some cases, the actual choice of material is left to the grower. One respondent indicated the need for growers to rotate chemicals (carbamates and organophosphates) and another indicated that growers are switching to Furadan (from Counter) because of safety.

7. From an applicator-safety standpoint, which granular chemicals do you most frequently recommend for corn pest

control?

The following chemicals were listed with the frequency of response indicated in parenthesis: Counter (3), Diazinon (1), Dyfonate (1), Furadan (8), Force (2), Lorsban (9), and Pounce (1).

Other comments were, "All have equal safety records" (2 responses), and "Furadan is dust free and safer to use" (2 responses). One respondent stated that Furadan is the only granular carbamate, most others are organophosphates, and resistance management is a factor.

PART IX. CONCLUSIONS AND RECOMMENDATIONS

IX(A). Summary and Conclusions

Furadan 15G is currently registered for control of some of the most economically important pest species (corn rootworms, European corn borers, nematodes) that attack field corn, sweet corn, and popcorn. Furadan 15G is reasonably efficacious against most insects and nematodes that attack corn, and it is considered by many entomologists to be the most effective insecticide for control of European corn borers. Some entomologists consider Furadan 15G to be the most effective product for control of chinch bugs, flea beetles, and stalk borers. Some plant pathologists consider Furadan 15G to be the most effective corn nematicide.

Furadan 15G is registered for planting time, cultivation time, and foliar applications, so it offers some flexibility in application method and placement. It can be applied directly into the seed furrow without causing phytotoxicity to corn seedlings. The formulation of Furadan 15G is unique (carbofuran is coated on the outside of sand granules), flows smoothly during application, and creates very little dust.

Furadan 15G is a systemic insecticide, so its application at planting can often be expected to control certain insects, like flea beetles and chinch bugs, that feed above ground on the corn seedlings. These insects ingest carbofuran that has been taken up by the roots and distributed to aboveground plant parts. Furadan 15G is also in a different chemical class (carbamate) than most of the other soil insecticides (organophosphates). This difference makes Furadan a potentially valuable tool in resistance management.

The use of Furadan 15G also presents some unique potential problems. It is quite susceptible to enhanced microbial degradation when it is used repeatedly on the same soil. This rapid breakdown process can render Furadan 15G biologically

inactive, so control failures are a potential consequence. The high solubility characteristic of Furadan 15G indicates that in certain permeable soils, carbofuran can leach into ground water and become a contaminant. The Furadan 15G label indicates that this is a potential problem. Furadan 15G is also toxic to fish, birds, and other wildlife. The Furadan 15G label indicates that birds feeding on treated areas may be killed, and that birds killed by carbofuran pose a hazard to birds-of-prey.

The pesticide impact assessment survey described in this report revealed some of the risks and benefits of both continued and cancelled use of Furadan 15G in corn. The responses to the use-data survey indicated that Furadan 15G is used on a significant percentage of corn acreage (14%) in the U.S., but it is not used on a majority of corn acreage. Cost and effectiveness comparisons of Furadan 15G versus chemical alternatives were analyzed to determine the potential economic results if Furadan 15G were withdrawn and alternatives were used. In general, the results revealed that if Furadan 15G were withdrawn and alternatives were used for control of soil insects, estimated losses would be expected to be greater in the southern U.S. where Furadan is considered to be the most effective product for several species of insects and nematodes. However, for the Corn Belt states, the data indicated that switching from carbofuran to chemical alternatives would result in a positive economic net return for most of the states. Most states indicated that the chemical alternatives were cheaper and the economic return of corn yield would not change or would increase if carbofuran were withdrawn and alternatives were used. A few states indicated that switching from carbofuran to chemical alternatives would be slightly more expensive in terms of production costs but would involve no change in economic return of crop yield.

The data analyzed for comparisons of costs and effectiveness of Furadan 15G versus chemical alternatives indicated that carbofuran is a more effective product than the alternatives for control of European corn borers. The expected economic return of crop yield would decrease if carbofuran were withdrawn and alternatives were used.

Most of the respondents that answered the questions regarding environmental and applicator safety concerns in reference to the use of carbofuran and other insecticides indicated that they had no more worries about Furadan 15G than they had with most of the other insecticides. However, those that had more concerns about Furadan 15G than other soil insecticides cited potential ground water contamination and potential effect on nontarget species (birds and earthworms) as areas of greatest concern. Nonetheless, 24 of the people who responded to the questionnaire said that they were not aware of documented kills of birds or other wildlife in their respective states.

The concern about the effects of Furadan 15G on birds revolved

mostly around the fact that some granules are not incorporated or covered with soil after application. As a consequence, birds may ingest these granules and die. Much concern was expressed about granules left exposed on the soil surface when the applicator boxes do not shut off when the planter units are lifted out of the ground. This occurs primarily at row ends when the planter is being turned. Solutions to the problem of exposed granules included complete incorporation of granules, in furrow applications, shut-off devices that would prevent leakage from applicator units at row ends, and avoidance of spills.

The overall conclusions were that the loss of Furadan 15G would not create many significant economic losses, with possible exceptions in the South (soil insects and nematodes) and for European corn borer control. However, the loss of Furadan 15G would virtually eliminate one chemical class (carbamates) from the soil insecticide market. The loss of an alternative class of chemicals could seriously disrupt resistance management programs for which chemical rotation is a management tool.

IX(b). Recommendations

1. Serious efforts should be made to document bird kills and other wildlife deaths so that the risks of using certain pesticides can be analyzed more scientifically.

2. Research should be conducted to solve the problem of leaving insecticide granules exposed on the soil surface.

3. Specific application techniques and/or shut-off devices that eliminate the exposure of soil insecticide granules on the soil surface should be recommended as soon as possible, if research evidence exists that these exposed granules pose a serious threat to birds and other wildlife.

4. A vigorous risk analysis of removing one class of chemicals from an insecticide resistance management scheme should be conducted.

5. Furadan 15G should be cancelled only if the potential risks of continued use of the product, analyzed vigorously and scientifically, outweigh the potential economic, safety, and management benefits documented in this report.

EPA REGISTRATION OF FURADAN

Furadan (carbofuran), -(2,3-Dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate) is registered with EPA by FMC Corporation for use on soybeans. Both the 10% (EPA registration number 279-2712 M) and 15% (EPA registration number 279-3023) granular formulations are registered for use on soybeans. Only one insect, the Mexican bean beetle, is listed to be controlled by carbofuran granular formulations and are applied at planting as either in-furrow or as a 7-inch band application.

These same granular carbofuran formulations are registered for controlling nematodes (root-knot, cyst, stunt, ring, sting, spiral, lesion, lance, dagger, and stubby-root) which are also applied at planting as either in-furrow or 7-inch band applications. The nematode registration is for 1.5 to 2.0 lbs. of a.i./acre whereas the Mexican bean beetle registration is for 1 to 1.5 lbs. of a.i./acre.

Specific Use Analyses

Soybeans are a major crop grown in the United States as nearly 60 million acres are planted each year. Listed below are the 4-year average figures for the year 1985-1988[1].

Planted Acres	Harvested Acres	Yield (bu/acre)	Production (bu.)
59,940,000	58,282,000	31.7	1,853,930,000

The season average price for these 4 years is $5.44/bu. which would assign an average annual value of $10,085,379,200 for the entire U.S. soybean crop. Of the 307 million U.S. cropland acres, soybeans are grown on 19.1%. Only corn (22.0%) and wheat (21.4%) exceed soybeans in the number of acres grown. The U.S. production comprises 42.7% of the world production followed by Brazil (21.3%), China (13.2%) and Argentina (11.7°/0)1. Over 50% of the U.S. acres of soybeans are grown in the 5 midwestern states of Illinois, Iowa, Missouri, Minnesota and Indiana.

Use of Furadan and Alternatives

Although several southeastern states list furadan 10G and 15G in their nematode control recommendations, less than 50,000 acres are treated with this nematicide. Resistant varieties and crop rotation are the preferred methods of controlling nematodes on soybeans. Other nematicides, ethoprop, fenamiphos, dichloropropene and aldicarb are also recommended but used very

sparingly for control of nematodes on soybeans.

Mexican bean beetle infestations are controlled by a parasitic wasp, *Pediobius foveolatus* or by insecticide spray applications when threshold populations are reached rather than preventive planting time applications of granular insecticides such as carbofuran.

Although several defoliating insects attack soybeans, spray applications are applied to control these insects if and when threshold populations are reached.

Not directly involved in this assessment, but yet very important consideration regarding carbofuran and soybeans, is the carbofuran 4F formulation.

If the granular formulation labels to carbofuran are rescinded, is the carbofuran 4F market large enough to continue a profitable market and justify the continued manufacture of carbofuran? Furadan 4F is used to control grasshoppers and other defoliating insects on corn, soybeans and alfalfa as well as other crops. Carbofuran 4F is an effective and economic insecticide that would be missed by growers if it was no longer available.

ALFALFA

IV. Specific Use Analyses

A. Current Registered Uses of the Pesticide by Site/Commodity

1. Registration summary
Carbofuran (Furadan 4F) on alfalfa.

2. Pest damage and infestation information (controlled and uncontrolled situations)

Not available.

3. Pest management recommendations

Not available.

4. Actual on-farm use data (Appendix L):

a. Percent of site/commodity treated and area of the country
States participating in the survey 23 (NJ, VT, IL, MS, CT, KS, ND, NE, NH, SC, OH, ME, AL, RI, NY, NC, GA, MO, TN, KY, IA, FL, WI) report 9,170,800 acres of alfalfa produced, of which 2,295,276 acres are infested to the point that insecticide application is needed (approx. 25%).

b. Variability in usage--year-to-year and area of country

Meaningful data were not uncovered. Some states reported no pest problems during some of the years, others reported more than one pest and damage on more than one cutting.

c. Frequency of application and number of applications per growing season

One-two applications per season, with one application being most common.

d. Active ingredient applied per unit area

0.5-1.0 lb. ai/A but 0.5 lb. ai/A was most common.

5. Crop systems and practices

a. Age of crop at treatment.

Alfalfa is a perennial crop; most applications take

place on the first crop of the season.

b. Application methods

Broadcast application by ground-driven or aerial application equipment.

c. Frequency of application and number of applications per growing season

Data unavailable.

d. Relationship between pesticide uses and cropping systems Perennial crop--annual crop rotation not an alternative. Major pests are highly mobile and crop rotation is, therefore, not a major alternative

e. Integration of pesticide use with good management practices

When crop phenology allows, manipulation of time of harvest of the first crop can control alfalfa weevil larvae in some instances. However, when populations escape this and other natural control practices insecticide application is the only remaining alternative.

Scouting for the presence of major pests as opposed to calendar treatment can reduce needless insecticide applications. No commercially available varieties expressing antibiosis exist, although varieties expressing tolerance resistance can be included in pest management programs.

6. Potential for pest resistance

Sufficient classes of insecticides exist, along with a large untreated reservoir, to make pest resistance unlikely.

B. Alternative Management Practices **by Site/Commodity**

See A.5 above.

C. Economic & Social Impacts by Site/Commodity (Appendix M)

1. Methodology and data (crop yield/quality, efficacy/value)

Total acres in survey (23 reporting states)--9,170,800 acres.
Average yield per acre--3.24 tons.
Average value/A--3.24 T/A x $81.63/T = $264.48.

2. Quantitative use analysis of the review pesticide

and/or alternative(s)

2,295,276 acres treated per year (5-year average) and this represents approximately 25% of the total acreage.

Compound	Average Acres Treated	Percent of Total
carbofuran (Furadan 4F)	787,390	34.3
malathion	105,579	4.6
chlorpyrifos (Lorsban)	761,973	33.2
phosmet (Supracide)	59,673	2.6
methyl parathion (Penncap-M)	185,903	8.1
methidathion (Supracide)	59,673	2.6
carbaryl (Sevin)	137,706	6.0
Others*	197,379	8.6

*Malathion & methoxychlor, diazinon, thiodicarb (Larvin) dimethoate (Cygon) occasionally noted in the survey results.

3. Comparative cost-effectiveness of the review pesticide use and/or alternatives

Product	($/A) Chemical Cost
carbofuran (Furadan 4F)	7.31
chlorpyrifos (Lorsban)	9.45
*permethrin (Ambush/Pounce)	7.00
methyl parathion (Penncap-M)	4.88
carbaryl (Sevin)	3.85
methidathion (Supracide)	9.10
malathion	3.88
phosmet (Imidan)	5.25
**Others	5.52

*Registered for use during 1988, therefore, no other survey data are available. Surveyed individuals suggested substantial replacement of carbofuran acreage if this compound is lost. Extension newsletters from 1989, however, indicate substandard control of heavy alfalfa weevil population with permethrin.

**Remainder grouped because of low individual reported usage.

Relative effectiveness of replacement insecticides

Product	(Net Tons) Yield Reduction	Return ($) Per Acre
malathion	.49	65.96
chlorpyrifos	.15	75.82
phosmet	.53	71.04
methyl parathion	.32	76.06
methidathion	.31	71.92
carbaryl	.16	81.00

4. Impacts of non-use (cancellation) of the review pesticide and non-use of any alternative(s).

Survey esults suggest a 30 percent decline in alfalfa yield if all insecticides were lost.

5. Commodity/market impacts

6. Consumer impacts

7. Related economic impacts (including macro-economic considerations)

8. Social/community impacts

5-8. (above) Exact values undetermined, however, shortages of forages that resulted would lead to reduced profitability for growers and increased costs for meat and milk.

V. Exposure Considerations (Biological effects) (Appendix N)

A. Impact on non-target organisms
B. Impact on agricultural workers, applicators (see pp. 109-119 of Benomyl Report)
C. Impact on water quality
D. Residual control effects

A-D.(above) The survey uncovered no incidents in this area, however, no detailed studies of this particular area are known to exist.

VI. Conclusions and Recommendations (integrated summary)

Insecticides play an integral role in the management of alfalfa pests. Survey data suggest that in some areas, alfalfa could not be grown without the assistance of insecticides.

IV. Use Analysis for Banana

A. 1. **Site**

Banana (Hawaii & Puerto Rico only)

2. **Pest damage and infestation information.**

The banana root borer, Cosmopolites sordidus, was discovered in Hawaii on the island of Oahu in 1981. Yield losses approximate 85% if no control is used. Even with chemical (carbofuran) control, losses approximately 20% 30 days after treatment. Without control, banana production in Hawaii would cease as a commercial enterprise. The banana root borer was discovered in Puerto Rico in 1921 and in Florida in 1919. In Puerto Rico it is one of the most destructive pests attacking plantains and bananas. Thirty percent of banana and plantain losses in Puerto Rico ar attributed to the banana root borer. In Florida it attacks both bananas grown as ornamentals and those grown for human consumption, a relatively new industry. The larval stages of the pest injure the banana plant by feeding and tunnelling in the rhizome with subsequent damage leading to severe losses in production. Hidden within the plant the larvae are well protected and control measures can more practicably be directed at the adult weevils which hide in the leaf sheaths of the plant or in trash on the ground, coming out at night to feed and lay their eggs.

Extensive feeding damage by grubs results in root destruction, slowed plant growth, reduced fruit production and, sometimes, toppled plants.

3. **Pest Management**

In Hawaii, the infested area is under quarantine. Pest management depends on user's monitoring their own fields. The Hawaii DOA also surveys for pest outbreaks in non-quarantined areas. The borer has been found in relatively isolated areas on three islands. Chemical control is recommended only if borer populations exceed an action threshold. Both adults and larvae are controlled with a single yearly application of Furadan 5G.

An integrated pest management program has been instituted in Hawaii to reduce the spread of the borer. Plant-clumps or mats must be cleared of plant debris including harvested plants. The stumps are removed and the corms cut into 4 to 8 pieces to dry. This prevents larval development. Planting material is inspected when moving to new fields. Leaf sheaths and corms are trimmed to remove eggs and larvae from planting material. A hot water dip of the corm has given very limited control of eggs and larvae and is labor intensive. Traps consisting of split pseudostems or stumps are used to estimate field populations. Insecticidal treatment is recommended when counts exceed action levels. In Hawaii, both adults and larvae are controlled with a single yearly application of Furadan 5G. In Puerto Rico the borer is controlled primarily with three applications of either aldicarb or carbofuran. Some areas are also treated with oxamyl or ethoprop.

4. Actual on-farm use data.

a. In 1988 approximately 10% of the total banana acreage in Hawaii (1220 acres) was treated with Furadan 5G. All of the acreage in Puerto Rico must be treated with an insecticide to control the borer. Approximately half of the 12,000 acres of plantain and 9000 acres of banana are treated with carbofuran. The remainder is treated with aldicarb and, to a lesser extent, with ethoprop or oxamyl.

b. In Hawaii usage is expected to increase as the borer spreads. Usage of carbofuran in Puerto Rico may increase if the use of aldicarb on banana and plantain is discontinued.

c. A single yearly application of Furadan 5G is made in infested areas in Hawaii. In Puerto Rico, applications are made at planting and at 4 month intervals.

d. According to the Hawaii Dept. of Agriculture 4500 lbs. of Furadan 5G were purchased by banana growers in 1988. The DOA estimated that approximately 125 acres were treated. As the borer continues to spread the amount of Furadan 5G used could increase to ca. 45,000 lbs.

In Puerto Rico approximately 10,000 acres are treated with Furadan 5G or 10G with the 10G predominating because of acid soils. Each mat receives 1-1.5 oz. at planting and at 4 and 8 months post-plant. The amount of active ingredient is a function of the number of mats per acre.

5. Crop systems and practices.

a. Bananas are continuously cropped throughout the year. Application is applied to a "mat" which generally includes both immature suckers and mature banana plants.

b. Furadan 5G is broadcast with a "cyclone' applicator on a mat-by-mat basis, i.e., inter-row areas are not treated. In Puerto Rico, Furadan is applied as a band application around the pseudostems. Carbofuran is also applied in the planting hole prior to the introduction of the corm, and then again 4 and 8 months post-planting.

c. Banana production is generally limited to areas receiving generous rainfall. In Puerto Rico bananas are intercropped with immature coffee and citrus orchards providing both shade and a temporary cash crop.

Carbofuran has not been found in any water samples analyzed to date. Groundwater is at considerable depth in areas supporting banana production on the island of Oahu. Groundwater is brakish in areas supporting banana production on the island of Hawaii, i.e., it is not potable.

d. Because bananas are grown in continuous culture, they are not rotated. However, in some coffee growing areas in Puerto Rico, bananas or plantains are intercropped with young.

e. Carbofuran is a Restricted Use Pesticide and, as such,

is only applied by certified applicators. Ethoprop (Mocap)is the only other insecticide/nematicide registered for use on banana in Hawaii. However, ethoprop is not effective or amenable to banana root borer control in Hawaii.

At present, there are no effective alternative management practices, i.e., chemical control is essential. The Hawaii-DOA is currently looking for biocontrol agents for the borer. The use of 5G would be consistent with a bicontrol program assuming parasite(s) and predators can be found, screened and established. Application is not on a calender basis, but occurs only after monitoring with traps.

Because of known or suspected applicator poisoning in Puerto Rico carbofuran is applied by trained teams who work for the government. At present the use of carbofuran is rotated with aldicarb and to a lesser extent with oxamyl, ethoprop and Dasinit.

6. Resistance.

The relatively long life cycle of <u>Cosmopolites</u> <u>sordidus</u> and infrequent number of carbofuran applications mitigate against rapid development of resistance.

B. Alternative Management Practices.

1. Aldicarb, oxamyl, ethoprop and Dasinit are also registered for use on bananas to control the banana root borer. In Puerto Rico, aldicarb is equally effective as carbofuran in controlling this borer. (In Hawaii, only carbofuran is used to control the borer.)

2. See A2 above
3. See A3 above
4. Actual on farm use data.

a. In Puerto Rico approximately 10,000 acres are treated with aldicarb. This would probably double if carbofuran was not longer available.

b. Aldicarb is rotated with carbofuran in Puerto Rico. There are no rotational pesticides used in Hawaii.

c. Aldicarb is used at 1/3 to 1 oz. per plant at planting and again at 6 month intervals. Ethoprop is sometimes used at 2-3 oz/application and repeated three times during the growing cycle (11-16 months).

d. See above.

C. Economic and Social Impact

1. If no insecticide is used, it is estimated that Hawaii's crop yield could drop by 85% in areas infested with the banana root borer. No grower could survive with 85% loss, i.e., commercial banana production would cease in all areas infested with the borer.

In Puerto Rico, growers would have to rely on aldicarb, oxymyl,

ethoprop and Dasinit. These products are all more expensive than carbofuran and the latter three are less effective. Losses would likely increase as would the use of alternative insecticides. It is estimated that 30% of the bananas and plantains would be lost if the root borer was not controlled.

2. In 1988, 4500 lbs of Furadan 5G were used on bananas in Hawaii. Ethoprop was not used at all. Ethoprop must be incorporated with a rake or irrigated in. As a result, it will not control adult weevils. (However, it appears to be a decent nematicide.) At 34 lbs 10G/A three times per growth cycle, nearly 100,000 lbs ai would be used in Puerto Rico (x of 3oz/plant/cycle x 400 plants/A x 10,000 A x .1 lbs ai/16 oz).

3. The average yield in Hawaii is 10,700 lbs/A. An 85% loss would be ca. 9100 lbs. At 29.7 cents/lb. (grower price), this is $2700/A loss. The cost of application is approximately $140/A. This represents a 19.3:1 benefit/cost return.

By implementing a quarantine and IPM program, current losses have been confined to Oahu. The estimated losses on Oahu without the use of carbofuran are estimated to be approximately $243,000 (125A x 7400 lbs/A x 32.8 cents/lb) minus ($140/A application cost) times (85% loss.) The extent of the loss will increase as the weevil spreads.

Puerto Rico's plantain and banana crops are valued at $40.6M and $10-11M respectively. Unchecked the banana root borer will destroy approximately 30% of the crop. However, aldicarb is, at present, a viable substitute. If aldicarb use was cancelled, then losses would very likely increase as none of the presently registered alternatives are as effective as either aldicarb or carbofuran.

4. Cancellation of carbofuran on banana could eventually mean the end of commercial banana production in Hawaii. The 1988 value of the banana crop increased to $3.3.M. The 1989 value will be even higher.

5. See above.

6. All bananas in Hawaii would have to be imported. Since imported bananas are more costly than local bananas, there would be a slight increase in consumer price.

7. In Hawaii land currently used for bananas is of limited use in production of other crops. In fact, banana production is viewed as a viable alternative to sugar production, a declining industry in Hawaii.

8. There are approximately 175 banana farms in Hawaii. These growers and their employees would have to find alternative employment.

V. A. In Hawaii, there are no known impacts on non-target organisms, including birds. This may not be the case in Puerto Rico; however, documentation is lacking.

B. Apparently carbofuran has been implicated in applicator illnesses in Puerto Rico. In response, the government has taken

responsibility for applying the material.

C. There is no known contamination of ground or surface water.

D. Because bananas are monocropped in Hawaii, there are no adverse residual effects. In Puerto Rico carbofuran is only used in areas dedicated to banana production or on bananas intercropped with coffee and citrus, both of which have established carbofuran tolerances.

VI. Conclusions/Recommendations

In Hawaii, carbofuran is the only registered pesticide known to provide effective control of the banana root borer. It's loss could have a major economic impact on commercial banana production in Hawaii. Furadan 5G is applied with a backpack cyclone applicator or as a band to a relatively defined area (i.e., a mat) once/year. The economic returns are substantial. Cost of application is approximately $140/A.; yield/A. is ,$2427, 85% ($1944) of which would be lost without carbofuran ((.85) ($2427-$140) = $1944). Oahu losses without carbofuran would total approximately $243,000. In Hawaii, there are no known bird kills associated with carbofuran use on bananas, nor has it been detected in groundwater. This may be due to its rather limited use. Because carbofuran is fairly effective, use is not expected to increase in areas currently infested with the banana root borer.

The loss of carbofuran in Puerto Rico would result in the increased reliance on aldicarb and to a lesser extent oxamyl, ethoprop and Dasinit. As a result banana production costs would increase.

CARBOFURAN USE ON PLANTAINS, BANANAS in PUERTO RICO

BANANAS

Total cdas.* harvested 1988. 9,039
Production (million fruits). 571
Value (million $). 9
Approximate area treated (cdas.*)
    Any insecticide-nematicide. 85%
    Carbofuran. 25%
Dosage (gms. a.i./plant) . . . . 2.5[1]
Frequency. . . .(at planting and then twice/year)
Cost ($/lb). 1.50
Alternatives:
    Aldicarb (1.0-3.0 gm a.i./plant at planting and every 6 months)
    Ethoprop (6.0 gm a.i./plant at planting and every 6 months)
    Oxamyl (1.2-2.4 gm a.i./plant at planting and every 4 months)

PLANTAINS

Total cdas.* harvested 1988 ('000). 10.0
Production (million fruits) 318.6
Average production per cda.* ('000) 35.0
Value (million $) 40.7
Approximate area treated (cdas.*)
    Any insecticide-nematicide 85%
    Carbofuran 25%
Dosage (gms. a.i./plant) . . . . 2.5[1]
Frequency . . . .(at planting and then twice/year)
Cost ($1b). 1.50
Alternatives:
    Aldicarb (1.0-3.0 gm a.i./plant at planting and every 6 months)
    Ethoprop (6.0 gm a.i./plant at planting and every 6 months)
    Oxamyl (1.2-2.4 gm a.i./plant at planting and every 6 months)

* cuerda = .97 acres
1 average of 1,000 per acre

Appendix A
BANANA PRODUCTION IN HAWAII

BANANAS: Number of farms, acreage, yield, production, price and value, by islands, 1983-1987.

Yr	Farms	Acreage In Crop	Acreage Harvested	Yield Per Ac (harvested)	Prod.	Farm Price	Value Sales
	#	Acres	Acres	1,000 pounds	1,000 pounds	Cents /lb	1,000 $
			STATE[2]				
1983	183	1,100	860	5.2	4,470	31.2	1,395
1984	180	990	870	10.2	8,900	30.0	2,670
1985	178	1,060	840	9.7	8,160	30.3	2,472
1986	185	1,140	980	9.9	9,700	30.0	2,910
1987	175	1,220	1,070	10.7	11,400	29.7	3,386
			HAWAII				
1983	31	365	205	12.6	2,580	26.4	681
1984	32	330	305	10.3	3,140	28.3	889
1985	35	385	260	12.5	3,240	27.5	891
1986	41	440	370	9.5	3,500	28.0	980
1987	32	480	380	14.8	5,610	29.1	1,633
			KAUAI				
1983	33	115	95	4.9	470	31.0	146
1984	35	135	110	18.9	2,080	23.6	491
1985	34	155	145	13.7	1,990	26.5	527
1986	40	155	135	15.3	2,070	25.9	536
1987	38	145	145	13.5	1,960	25.1	492
			MAUI/MOLOKAI				
1983	21	80	65	4.6	300	25.8	77
1984	20	75	65	8.2	530	27.7	147
1985	19	65	45	7.2	325	29.2	95
1986	16	70	50	10.0	500	30.6	153
1987	12	70	70	4.6	320	34.3	110
			OAHU				
1983	98	540	495	2.3	1,120	43.8	491
1984	93	450	390	8.1	3,150	36.3	1,143
1985	90	455	390	6.7	2,605	36.8	959
1986	88	475	425	8.5	3,630	34.2	1,241
1987	93	525	475	7.4	3,510	32.8	1,151

[1] As of February following year, i.e., acreage data shown for 1987 is as of February 1988.
[2] Island totals may not add to State totals due to rounding.

BANANAS: Acreage by variety, State of Hawaii, February 1, 1988

Island	Brazilian[1] (Apple)	Bluefields[2] (Gros Michel)	Variety: Cavendish — Chinese	Variety: Cavendish — Williams Hybrid	Variety: Cavendish — Robusta[3]	Others[4]
Hawaii	35	5	*	370	70	*
Kauai	30	15	*	100	*	*
Maui/ Milokai	15	10	*	35	5	5
Oahu	385	*	15	105	5	15
Total	**465**	**30**	**15**	**610**	**80**	**20**

* = Less than 5 acres. [1]Includes Dwarf "Apple".
[2]Includes "Cocos" or Dwarf Bluefields. [3]Includes Taiwan.
[4]Includes cooking and Lady Finger.

BANANAS: Acreage by variety, State of Hawaii, February 1, 1988

Island	Brazilian[1] (Apple)	Bluefields[2] (Gros Michel)	Variety Cavendish Chinese	Cavendish Williams Hybrid	Cavendish Robusta[3]	[4]Others
Hawaii	35	5	*	370	70	*
Kauai	30	15	*	100	*	*
Maui/ Milokai	15	10	*	35	5	5
Oahu	385	*	15	105	5	15
Total	**465**	**30**	**15**	**610**	**80**	**20**

* = Less than 5 acres. [1]Includes Dwarf "Apple".
[2]Includes "Cocos" or Dwarf Bluefields. [3]Includes Taiwan.
[4]Includes cooking and Lady Finger.

POTATOES

Potato (Solanum tuberosum L.; also called "Irish potato" or "white potato" in some areas of the U. S. to distinguish it from sweet potato, Ipomoea batatas L.) is a staple crop that is grown commercially in more than half of the states, although the top seven states (ID, ND, WA, ME, MN, CO, WI) account for about 70% of the acreage (Tables 1a, 1b). It is subject to attack by numerous pests for control of which carbofuran products have been registered.

SPECIFIC USE ANALYSIS

REGISTRATION SUMMARY

Carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) products are registered for control of several pests of potato in the U. S. The federal labels for the most commonly used granular formulations, Furadan 15G and Furadan 10G, specify use for potato to control Colorado potato beetle, European corn borer, potato flea beetle, potato leafhopper, tuber flea beetle, green peach aphid (Western and Northeastern states including the Delmarva Peninsula), potato tuberworm (Virginia only), and to aid in control of wireworm, at 1.5 lb formulation per 1000 ft of row (20 lb per acre with 38-inch row spacing). It is to be applied directly into the bottom of the seed furrow during the planting operation.

"State" labels (Special Local Needs registrations, FIFRA Section 24-c) permit use of granular carbofuran as Furadan 15G for Colorado potato beetle, potato flea beetle, green peach aphid, and potato tuberworm in North Carolina, and for nematodes to aid in control of corky ringspot (a disease caused by a virus that is vectored by stubby-root nematodes) in Florida.

The liquid product, Furadan 4F, is registered for potato tuberworm (Virginia only), Colorado potato beetle, European corn borer, potato flea beetle, and potato leafhopper. It is to be applied as a foliar spray at 1 to 2 pts per acre from first appearance of target insects and as needed to maintain control thereafter but no more than 8 foliar applications per season (no more than 6 pts if granular carbofuran was used at planting).

A "state" label (Special Local Needs registrations, FIFRA Section 24-c) permits foliar application of carbofuran as Furadan 4F for Colorado potato beetle in Oregon.

PEST DAMAGE AND INFESTATION INFORMATION

A survey instrument was sent to Pesticide Coordinators of all states to gather information about recent usage of carbofuran products in potato throughout the U. S. Telephone calls were made to follow up on the questionnaires in some cases. Responses from 33 states which reported some commercial potato production are summarized in this report.

Information requested from state contacts included target pests against which carbofuran and registered alternative products were used, as well as application timing, methods, and

rates. Target pests in various locations included Colorado potato beetle, potato tuberworm, European corn borer, potato flea beetle, potato leafhopper, and nematodes.

Colorado potato beetle: Distributed throughout most of the U.S., both adults and larvae feed on foliage and terminal growth of potato plants. They commonly cause severe damage to foliage.

European corn borer: Found in much of the eastern, northeastern, and midwestern U.S., the caterpillars of this moth are known to feed on over 200 host plants, boring into any plant organ big enough to accommodate them. They can cause severe damage to potato vines.

Potato flea beetle, tuber flea beetle: Flea beetles are small beetles with enlarged hind legs, enabling them to leap long distances when disturbed. Adult feeding causes small shot-holes in foliage, sometimes so numerous that leaves collapse. Larvae of the tuber flea-beetle bore into potato tubers; it is an important pest in the western U.S. Adults are sometimes vectors of early blight disease.

Potato leafhopper: This small hopper feeds on undersides of potato leaves, removing sap and causing "hopperburn;" it may vector some diseases. It is found throughout the eastern and midwestern U. S.

Green peach aphid: Aphids feed by sucking sap from leaves and young stem terminals; heavy feeding curls and distorts leaf growth. They are vectors of many viruses. One or more aphids can be found everywhere potatoes are grown in the U.S.

Potato tuberworm: Youngest larvae of this moth may feed as blotch leaf-miners, but older (larger) instars burrow in stems or work their way into tubers (before or after they have been dug). Their tunnels ruin potato tubers. The insect is a serious potato pest in some eastern states.

Wireworm: Wireworms are the larvae of beetles of the family Elateridae (click beetles), found throughout the U.S.. Several species can cause severe damage to tubers by burrowing in them.

Nematodes: Several species of nematodes are serious pests of potato by direct effects of their feeding in/on the roots or tubers. In addition, Trichodorid ("stubby-root") nematodes are vectors of the virus that causes corky ringspot disease (known only in Florida in the U. S.), and several Pratylenchus spp. ("lesion nematodes") have been clearly implicated in a complex with Verticillium wilt fungi that causes a disease syndrome sometimes called "early dying" or "early maturity."

PEST MANAGEMENT RECOMMENDATIONS

States in which carbofuran products are recommended for use are noted in Table 1a. Specific recommendations appear to follow maximum label rates. In many cases, state specialists have not recommended carbofuran products, even though registered, because of poor efficacy.

ACTUAL ON-FARM USE

The survey instrument was sent to Pesticide Coordinators in all states to gather information about actual recent usage of carbofuran products in potato crops throughout the U. S. Telephone calls were made to follow up on the questionnaires in some cases. Responses from 33 states which reported some commercial potato production are summarized in this report.

Those states which responded reported a total of 1,063,970 acres of potatoes, approximately 85% of the national acreage (1,259,300 acres reported for 1988 (1); for calculations in this report, average annual planting is taken to be 1,247,000 acres, based on 1986-88 data). Twenty of those states, representing (by their own estimates) approximately 273,470 acres of potato plantings, reported no use of carbofuran for potato. The 13 states which reported at least some use of carbofuran reported a total of 790,500 acres planted.

No data or observations were provided to assess variability of usage from year to year. However, usage is so low that even a doubling of usage from one year to the next would not have a significant effect on the total pattern of potato pesticide usage in most states.

Granular formulations of carbofuran are applied once per season, in the planting furrow. Essentially all respondents stated that the granular formulation was used at maximum label rate, which is 3.0 lb. a.i./acre. Although liquid carbofuran can be applied as a foliar spray at 1-2 pints/acre (0.5-1.0 lb. a.i./acre) up to 8 times per year (limited to 6 if granular carbofuran was applied at planting), most states stated that their normal pattern for the liquid was one to three applications per season. Thus, the liquid formulation appears to be used at about 2.0 lb a.i./acre annually, where it is used at all.

Thirteen states reported that approximately 18,840 acres were treated with Furadan 15G (about 1.8% of the total potato acreage reported by the 33 states that responded to the survey) and 43,700 acres (4.1% of acreage in respondent states) were treated with Furadan 4F for control of insects. Most respondents estimated there to be little or no effect of these products on quality or quantity of yield, generally stating carbofuran to be inferior to alternative insecticides, more expensive, or both. All who stated an opinion agreed that loss of the granular formulation would have no significant effect on potato insect control, and many expressed the same feeling for Furadan 4F. Idaho reported about 5,800 acres (<2% of its potato acreage, and <0.5% of the total acreage reported in this survey) treated with carbofuran granular for nematode control as well as insect control. There was no other mention of use for nematode control.

CROP SYSTEMS AND PRACTICES

As stated previously and as specified on the label, the granular formulation is applied into the bottom of the seed furrow at planting. The liquid may be used as a foliar spray any time up to 2 weeks before harvest, but most respondents indicated that carbofuran sprays were made early in the season, although they did not identify specific application times. Application is

apparently by air in many, perhaps most, cases. No information was supplied regarding proximity of non- treated crops, relationship of carbofuran use to cropping systems, or how it fits into overall management schemes.

POTENTIAL FOR PEST RESISTANCE

Carbofuran is clearly susceptible to development of resistance by target insects. One of the reasons cited most frequently by respondents that carbofuran products were not recommended or used was development of resistance to carbofuran by target pests. Colorado potato beetle was cited especially often as a pest that has developed strong resistance to carbofuran.

On the other hand, the single most important reason given by respondents that they did not want to lose the registration of carbofuran for potatoes was that it is one of few carbamate materials that can be rotated with organophosphate and pyrethroid insecticides, thus reducing opportunities for development of resistance to those materials, or providing an alternative to them if resistance should develop in an important target pest.

ALTERNATIVE MANAGEMENT PRACTICES

Respondents generally did not provide adequate detailed information about alternative chemicals and other practices to present a detailed analysis of their costs/benefits relative to carbofuran.

ECONOMIC AND SOCIAL IMPACTS

From comments on the survey forms, it is apparent that, in fact, carbofuran presently commands very little of the pesticide market for potato. It was described by many respondents as less effective, more expensive, or both, than the products that are predominant in each state. Many said that there would be no distinct effect on quality or quantity of yield by substituting alternative products for carbofuran. However, few provided specific information on rates of application, costs, etc. of those alternative products. From the few who did make partial estimates of differences in cost of using alternative products, it appears that use of more applications per season of some of them will increase the over-all cost of their use by a nominal sum, perhaps $1.00/acre. This minor scale of effect, combined with the very limited acreage that is now treated with carbofuran, limits the overall economic impact of such a change on markets, consumers, or the producer community.

Many respondents indicated that alternatives were more effective against the principal target pests than carbofuran. Colorado potato beetle has developed high resistance to carbofuran in NY and NC, dramatically reducing its value for control of that pest to growers in those states.

Carbofuran was cited as the most effective product against European corn borer by North Carolina but, paradoxically, that its loss would have little real impact on production.

Of all respondents reporting insecticidal use of carbofuran, most stated that its use had little or no real effect on potato quality or quantity in their states; only four provided quantitative estimates of benefits of carbofuran use: Arizona, Illinois, Kansas, and Minnesota. Overall, they estimated that value of the potato crop in those states was increased by about 1% over what those states' production value would be without carbofuran. Those states represent less than 7% of the national acreage and even less than that in net production; a 1% increase in yield on no more than 7% of the nation's total potato crop is insignificant.

Idaho reported about 5,800 acres (<2% of its potato acreage) treated with carbofuran for nematode control as well as insect control. There was no other mention of use for nematode control. Idaho estimated that this usage resulted in no change in yield, but increased the value of the crop (quality adjustment) by $1 per cwt. With a reported state average yield of 286 cwt/acre, that represents increased revenues of $286.00 per acre; after subtracting inputs, cost of product ($8.73/lb x 3 lb/acre = $26.19) + application ($1.00/acre) = $27.19 per acre, increased profit is $258.81. About 5,800 acres were treated with carbofuran for this purpose, so use of granular carbofuran in Idaho may result in a net profit of no more than $1,501,098. If half of that is attributed to nematode control, the total value of carbofuran for nematode control in potatoes in the U. S. may be about $750,000. Since national production is approximately 300-400 million cwt/year, worth over $2 billion, nematicidal use of carbofuran is clearly insignificant. In fact, although specific estimates of acreage treated with each product were not provided in enough states' responses to make a quantitative assessment of use, at least four other products are used as nematicides on more acres than carbofuran: ethoprop, metham-sodium, 1,3-D, and aldicarb.

Aldicarb, as Temik 15G, is by far the most widely used granular insecticide-nematicide whose use pattern encompasses the registered uses of Furadan 15G. It is generally considered more efficacious against both insect and nematode pests. Many respondents stated that carbofuran might be far more important in potato production if Temik were no longer available; aldicarb is presently undergoing Special Review.

EXPOSURE CONSIDERATIONS

IMPACT ON NON-TARGET ORGANISMS

The trigger for the ongoing Special Review of carbofuran granular products is avian toxicity. In response to a direct question on the survey instrument, none of the respondents indicated awareness of any avian toxicity problems in their specific states. Many indicated that adherence to current label directions to apply the granules in furrow at planting should avoid any risk of bird toxicity if the applicator were turned off well before reaching the end of the row so that all granules would be buried.

More respondents expressed concern about carbofuran's

potential for groundwater contamination, as well as the same risk for many of its alternatives. A few cited groundwater concerns as inhibitory to their recommending carbofuran products.

No respondent gave any indication of concern about any special risk to agricultural workers from use of carbofuran. There were no comments about unexpected residual control of any organism.

CONCLUSIONS AND RECOMMENDATIONS

The only conclusion supported by the statistical and narrative information provided by respondents (representing about 85% of the U. S. potato acreage) is that, overall, carbofuran is not important to potato production in the U. S. Its loss would not affect production or prices of potatoes. Specifically, no respondent attached any importance to the granular formulation, Furadan 15G, for any specific pest control problem in potatoes. The foliar use of the liquid formulation, Furadan 4F, was considered to be important for control of European corn borer in North Carolina, and its loss would be missed there. However, the impact of such loss on overall potato production would be negligible.

Thus, although the author does not feel that there is just cause to cancel registration of carbofuran products for potato pest control, he recognizes that there is little economic incentive for any registrant to maintain such a registration or pay the cost of data collection to support reregistration. Loss of registrations of several other materials that are presently used for the same purposes might make carbofuran more attractive in the marketplace and thus justify greater investment in it, but that is speculation based on very little evidence. Under present economic circumstances, it does not seem reasonable to expect continued registration of carbofuran products for potato pest control.

PEPPERS

No data collected.

STRAWBERRIES

Introduction

The United States is the world leader in strawberry production, with 20-25 percent of world production. About 580,000 tons are produced on 58,000 acres. California produces 68 percent of the U.S. tonnage on 25 percent of the acreage and has an average yield of 27 tons per acre compared to 4-5 tons per acre in the rest of the U.S. While the strawberry market will continue to rise as per capita consumption increases, acreage is expected to stabilize. Available labor represents a serious constraint to expansion of the industry. Current prices average about $0.60 per pound valuing California production as $32,000 per acre per year with much of the remaining U.S. production valued at $6,000 per acre. With such high valued crops even small yield losses can have significant economic impacts.

Carbofuran Use on Strawberries

Registration Summary: Carbofuran 4F is presently registered for the control of a complex of root weevil species on strawberries. This formulation only, has federal registrations in Oregon and Washington and special need labels in Calif., Ill., Mass., Minn., N.H., N.J., N.Y., Tenn., Va., and Vt. Granular formulations are not registered for use on strawberry.

Pest Information: Strawberry Root Weevils: In North America, about 200 species of insects and mites have been reported as pests of strawberry. About 75 of these species are beetles, of which the largest group are the weevils or snout beetles. Of the 20 or more species of root weevils on strawberry, members of the genus Otiorhynchus are of most cosmopolitan concern. These include the black vine weevil, O. sulcatus and the strawberry root weevil O. ovatus. Others of more regional interest include the woods weevil, Nemocestes incomptus and the obscure root weevil Sciopithes obscurus.

Damage: While adults of these and other species feed on the foliage, most damage results from larval root feeding. In the absence of control, crop damage by the second fruiting year may necessitate early termination of the planting. The effects on yield from intermediate damage levels due to larval feeding are difficult to determine. Cram and Andison found that in a 3rd year planting, 11.6 black vine weevil per plant resulted in a yield of 1.1 ton/acre vs. 2.5-3.0 tons where treatment resulted in no surviving larvae. In New Zealand, it was found that 208 larvae per plant resulted in economic damage.

Nine of the present survey respondents estimated a range in crop loss due to weevil feeding of from 25 to 75 percent by the 3rd fruiting year. Mean damage was 47 percent. Such estimates are difficult to determine with accuracy. It is clear, however, that once a field becomes infested, yield levels drop rapidly. The grower then must make the decision as to whether the planting remains profitable or whether it should be destroyed.

Control Recommendations: Chemical Control: Early recommendations for the control of adult root weevils in strawberry consisted of ground dried apples mixed with arsenic. While reasonably effective against adults, the environmental constraints to such a treatment are obvious. For example, the USDA at one time recommended a similar mixture for rodent control. Downes, noted that, "A certain amount of outlay on such (control) measures should be regarded by the grower as a necessity if small fruit culture is to be made a commercial success.". He recommended the use of sodium fluosilicate/raisin baits which he erroneously considered to have lower mammalian toxicity than arsenical baits. Eide in 1952, was the first to demonstrate the control of larvae by incorporation of the chlorinated hydrocarbons, aldrin, chlordane, and heptachlor into the soil. Cram and Andison and Cram found such soil treatments to be ineffective against the obscure root weevil and members of the genus Nemocestes. Eide demonstrated the effectiveness of EDB soil fumigation against this complex of weevil species. Malathion and/or DDT was reported effective against the obscure root weevil adults by Cram. The developing opposition to the persistent cyclodiene insecticides prompted Shanks to investigate alternate chemical treatments. While none of the organophosphorous or carbamate insecticides tested approached the effectiveness of aldrin, carbofuran was found to be highly promising against adults and larvae of black vine weevil. Rosensteil found a fall treatment of this material to be effective in the control of the rough strawberry weevil in Oregon. By 1976, carbofuran was being recommended for the control of all root weevil species on strawberry in Washington. The restrictions on chlordane, the observed resistance of black vine weevil to dieldrin, and the registration of carbofuran for weevil control in Washington and Oregon prompted tests on this compound in California. EDB was phytotoxic and the organophosphorous materials, malathion, guthion, diazinon, and Phosdrin, failed to limit weevil spread. Furadan was found effective against woods weevil and the cribrate weevil in those tests. To date there have been no alternative pesticides found effective against the weevil complex on strawberries.

Only the 4F formulation is registered for use on strawberries. Federal registrations in Oregon and Washington for the control of root weevils on this crop recommend that 1-2 qrts. (32-64 fl.oz.) of 4F (64 oz a.i./gal.) per 100 gallons of water per acre, or 2.65.1 fl. oz/1000 linear feet of row on 42 inch spacings, concentrated in a 10-12 inch band over the row. Restrictions prevent its use when berries are present.

Ten states have special need labels and the recommendations are similar to the Federal Labels in terms of rates and restrictions. In no state does the rate exceed 32 oz a.i. (64 oz. formulation) per acre and in most cases they are recommending 16-14 oz a.i.. Adequate control may be obtained with 8-16 oz. a.i./acre. Additional restrictions are cited depending on the cultural system used. Vermont, for example, recommends treatment following postharvest renovation and precludes treatment after September 1, or more than a single annual treatment.

Archer et al. reviewed the tolerance levels and persistence of this compound on strawberries. The established tolerance for carbofuran and phenolic metabolites in or on strawberries is 0.5

ppm, of which not more that 0.2 ppm may be carbamates. Previous work has shown that rates up to 32 oz. a.i. as a pre-bloom spray gave residues below 0.3 ppm. (Note; there are about 30 days from blossom to harvest) These workers applied 4 and 8 oz a.i. to maturing fruit of 3 strawberry varieties. The combined residues on the berries never exceeded the tolerance level of 0.5 ppm nor did the carbamate fraction exceed 0.2 ppm 6 days after application.

On-Farm Use Data: Survey forms in solicitation of information concerning strawberry production and root weevil control practices were sent to the 12 states having Federal or special need registrations for carbofuran (Table 1). The 10 respondents represented about 70 percent of the strawberry acreage in the U.S. and, with the inclusion of California, represent in excess of 90 percent of the U.S. production.

As was pointed out in the Introduction, California represents a unique production zone and would bias the national picture if not taken into consideration during the present discussion. Because of the annual production system used in California, strawberry plantings are not under enough continuous cultivation to permit root weevil build-up. Thus, this major producer does not require the use of carbofuran for this purpose. The remaining 9 respondents had average yields of 7,365 lbs. per acre, valued at an average of $0.60 per pound or $4,419.00 per acre. Sixteen percent of the respondents acreage received a single annual treatment of carbofuran with rates ranging between 16-32 oz a.i. per acre, for a total of 12,302 pounds a.i..

With no suitable alternative pesticides for root weevil control, it is estimated that the loss of carbofuran would result in yield reductions of 9,672 tons at an on-farm value of $8,764,418.00. The cost of material would reduce gain from treatment by $153,529.00 when $0.78 per oz. a.i. is used as the cost figure.

Table 1.-Use of Carbofuran 4F for root weevil control on strawberries in the U.S. , 1989.

State	Acres Grown	Pounds/ Acre	Price/ Pound	Acres Treated	Oz a.i./ Acre
Tenn.	2000	6000	$0.60	1000	24
Or.	7740	9386	$0.36	2709	32
N.H.	0350	7500	$0.72	0011	19
Ill.	2000	8666	$0.60	0100	16
Wash. (F)	2500	7233	$0.38	1000	32
Mass.	0478	6800	$0.61	0120	26
Minn.	1500	4000	$1.00	0225	32
Va.	1200	10,000	$0.60	0300	24
Calif.	19,600	48,000	$0.55	0000	16
N.Y.	3300	6700	$0.60	0990	32
Vt. and N.J.		No response			

Cropping systems: Except for the annual cropping system used in California, most states utilize a growing year followed by 2 or more fruiting seasons. Under the latter system, weevil damage is not noted until the second fruiting year, at which time the first carbofuran treatment would be applied. Because of the expense of the material, attempts are made to minimize dosages and treatments are made with ground equipment in a band over the row. This represents a single annual post-harvest, 10-11 month pre-harvest treatment. If rotating to another crop there would be 18-24 months pre-harvest.

Cropping practices often include the mowing and removal of plant foliage following harvest. This practice, if followed, provides for good soil surface coverage with the insecticide and a better opportunity to contact the emerging adult.

Potential for Resistance: To date there has been no evidence of resistance of strawberry root weevils to carbofuran. The maximum of a single annual treatment would not be expected to promote rapid build-up of such resistance.

Alternative Management Practices

While carabid and staphylinid beetles attack black vine weevil larvae, no parasites effective against root weevils (19) have been found. A strain of the fungus Metarhizium appears to have some promise.

It is evident that, with annual cropping such as practiced in California, root weevil will not be a major problem, thus reducing the need for furadan treatment on 68 percent of the U.S. strawberry acreage. Generally, root weevil becomes serious as a result of successive and intensive cropping. When the same planting is fruited over several years, insect numbers increase. When the plants are plowed under, the weevils migrate readily to adjacent plantings. Every effort should be made to reduce this migration. Barriers are not feasible. Some benefits may be gained by delaying plowing until fall thus using the old planting as a trap-crop for oviposition. Many mature larvae may survive plowing and fallow or rotation is necessary to make the strategy effective.

Cram observed O. sulcatus to cause significant yield reductions during the 2nd year of infestation at levels of 8 larva per plant. Other species caused similar reductions during the 3rd year. Some tolerance to O. sulcatus was observed with the strawberry varieties Totem and Cheam. Doss et. al. attributed resistance of clone Cl-S of the beach strawberry to O. sulcatus to the presence of leaf hairs. Further observations on host plant resistance have been reported. Preliminary findings on non strawberry hosts suggest some potential for nematode control of black vine weevil and strawberry weevil.

Exposure Considerations

Carbofuran is broad spectrum in activity and while its impact on most non-target arthropods is unknown, there is evidence that it is toxic to spider mite predators. Its use under some situations could result in a spider mite resurgence.

Special care is required to assure that no berries are on the plants at the time of treatment. These could represent a hazardous attractant to any herbivorous mammals or birds in the area. The practice of topping (mowing) the foliage following harvest will usually destroy any residual fruit as well as allowing the material to reach the soil surface where rain or irrigation can carry it into the soil where its effectiveness may be enhanced. This product can leach through soil and it should not be used on a light sandy loam soil there the water table is close to the surface of the ground. This precaution is of particular concern with a crop such as strawberries which prefer light soils and where irrigation is commonly practiced.

Conclusions and Recommendations:

With no effective alternative pesticides or economically viable control practices available it is recommended that carbofuran 4F be retained for the control of strawberry root weevils on this commodity. Because of variations in cultural practices throughout the U.S. it is recommended that label instructions be carefully tailored to local systems.

CURCURBITS

Current Use Analysis - Cucurbits

Introduction

In the United States, cucurbit production is located in four distinct regions of the country: California, southeast, midwest and northeast. Within these areas, carbofuran use is concentrated in the southeastern United states (Florida, Louisiana, and North Carolina), the Northeast (Delaware, Maryland and New Jersey) and in the Midwest (Illinois, Missouri and Ohio) (Table 1). Production in these states, for the cucurbits as a group, is estimated at 1,1,209,817 tons per year from a ca. 158,799 acres (average yield/acre - 7.6 tons). Of this total acreage, 41% is treated with carbofuran 15G (Table 2); 21,679 acres - nematodes, 27,637 acres - striped cucumber beetle, 15,687 acres - spotted cucumber beetle.

Table 1. Cucurbit acreage and yield estimates by state.

State	Crop	Acreage Planted	Yield/Acre (tons)	Yield (tons)
Delaware	Cucumbers	1,500	4.40	6,600
	Melons	1,500	20.05	30,075
Florida	Cucumbers	16,760	4.20	70,392
	Melons	55,330	8.40	464,772
	Squash	16,080	3.91	62,808
Illinois	Cucumber	800	4.20	3,360
	Melons	1,000		
	Pumpkins	5,500	22.00	121,000
Louisiana	Melons	4,000	10.00	40,000
	Pumpkins	300	9.00	2,700
Maryland	Cucumbers	4,200	7.50	31,500
	Melons	2,600	6.00	15,600
	Pumpkins	615	6.75	4,151
	Squash	410	6.50	2,665
Missouri	Cucumbers	200	9.20	1,840
	Melons	11,500	7.50	86,250
	Pumpkins	1,500	5.00	7,500
	Squash	200	5.00	1,000
New Jersey	Cucumbers	3,750	8.00	30,000
	Melons	1,500	20.05	30,075
	Pumpkins	500	6.00	3,000
	Squash	2,000	6.00	12,000
North Carolina	Cucumbers	7,239	5.03	36,399
	Melons	3,524	1.92	6,764
	Pumpkins	3,000	4.80	14,396
	Squash	4,808	4.82	23,169
Ohio	Cucumbers	4,500	10.50	47,250
	Melons	1,392	5.00	6,960
	Pumpkins	1,745	20.00	34,900
	Squash	846	15.00	12,690
	Total	**158,799**		**1,209,817**

EPA Registration of Furadan 15G:

Furadan 15G (carbofuran) is registered with EPA by FMC Corporation (EPA Reg. No. 279-3023) for use on cucurbits (Cucumber, Melons, Squash, and Pumpkins) to control nematodes (Root Knot, Sting, and Lance) in the southeastern United States only. For this use, the labeled rate is 1.5 lbs per 1,000 linear feet of row applied in a 12 to 15 inch band and incorporated into the top 3 inches of soil.

Table 2.Number of acres of cucurbits treated with carbofuran 15G by state.

		# of Carbofuran Treated Acres		
State	**Crop**	**Nematodes**	**Striped Cucumber Beetle**	**Spotted Cucumber Beetle**
Delaware	Cucumbers	0	1,125	0
	Melons	0	1,125	0
Florida	Cucumbers	1,676	0	0
	Melons	5,533	0	0
	Squash	804	0	0
Illinois	Cucumber	0	0	720
	Melons	0	800	0
	Pumpkins	0	4,950	0
Louisiana	Melons	800	0	0
	Pumpkins	90	0	0
Maryland	Cucumbers	0	1,260	0
	Melons	0	1,300	0
	Pumpkins	0	31	0
	Squash	0	41	0
Missouri	Cucumbers	150	150	150
	Melons	8,600	8,600	8,500
	Pumpkins	1,100	1,100	1,100
	Squash	150	150	150
New Jersey	Cucumbers	938	938	0
	Melons	375	375	0
	Pumpkins	125	125	0
	Squash	500	500	0
North Carolina	Cucumbers	362	0	0
	Melons	176	0	0
	Pumpkins	60	0	0
	Squash	240	0	0
Ohio	Cucumbers	0	3,375	3,375
	Melons	0	1,044	1,044
	Pumpkins	0	436	436
	Squash	0	212	212
Total		**21,679**	**27,637**	**15,687**

Furadan 15G also has several 24(c) labels registered with EPA (Table 3) for control of nematodes, striped cucumber beetle, and spotted cucumber beetle in cucurbits in states outside of the southeast. The labeled use rates for these applications are identical to the federal label for nematodes as mentioned above.

State Recommendations:

Of the 18 states (11 - 24(c), 7 federal) with the ability to use Furadan 15G on cucurbits, only 8 do so. The states of Florida, Louisiana and North Carolina recommend carbofuran for nematode control only. Delaware and Maryland recommend carbofuran for control of striped cucumber beetle. Illinois and Missouri recommend carbofuran for control nematodes, striped and spotted cucumber beetles and New Jersey recommends carbofuran for both nematodes and striped cucumber beetle. All recommendations are for at planting applications.

Table 3. States having 24(c) labels for carbofuran 15G use on cucurbits.

State	EPA Registration Number	Labeled Pests: Nematodes	Labeled Pests: Striped Cucumber Beetle	Labeled Pests: Spotted Cucumber Beetle
Delaware	DE830004		X	
Illinois	IL820001	X	X	X
Indiana	IN830001	X	X	X
Massachusetts	MA830003		X	
Maryland	MD830003		X	
Michigan	MI820025	X	X	
Missouri	MO860003	X	X	X
New Jersey	NJ830001	X	X	
Ohio	OH830002	X	X	X
Pennsylvania	PA840005	X	X	
Virginia	VA830009	X	X	

The highest percentage of acres treated are in Delaware (75% for both cucumbers and melons), and Illinois (90% of cucumbers and pumpkins, 80% of melons). In these states, as in others, applications are made to suppress bacterial wilt via control of its disease vectors, the striped and spotted cucumber beetle.

Registered alternatives include, for nematodes: Telone II (1,3-dichloropropene), Vydate L (oxamyl), and Mocap 15G and 6EC; and for cucumber beetles: Sevin 50W (carbaryl), Asana (esfenvalerate), and Lannate L (methomyl).

Use of Carbofuran and Alternatives

Cucurbits are grown commercially in the west, midwest, southeast and northeast. For those states in which carbofuran 15G is registered, Florida contains the highest total acreage (88,170), followed by North Carolina (18,571), Missouri (13,400) and Maryland (14,715). In addition to this, Delaware, Illinois, Louisiana, New Jersey all grow less than 10,000 acres. Total production ranks differently however. Florida leads all states with 597,972 tons, followed by Illinois with 124,360 tons, Missouri (96,590 tons), and Ohio (101,800 tons) (Table 1). North Carolina, New Jersey, and Maryland yield between 50,000 and 100,000 tons per year, and Louisiana and Delaware less than 50,000 tons.

Carbofuran use in all states reporting is via an in-furrow, band or broadcast at-planting application. In Florida (broadcast) and North Carolina (band) treatments are made to less than 10% of all acreage. Louisiana (band), Maryland (band) and New Jersey (band) report between 15 to 25% of total acreage treated with carbofuran 15G, 40% in Missouri (band), and 75% and 89% in Delaware (in-furrow) and Illinois (band) respectively.

In Delaware, 15% of all acreage is not treated. If carbofuran 15G is removed from the market, growers will need to apply either Asana, Lannate L or Sevin 50W. These applications will be applied by air and repeated 2-4 times a year depending upon the crop.

In Florida 70% of all acreage remains untreated, with 5% of acreage treated with carbofuran 10G and Vydate L, and 1% with Telone II. Florida, however, reports that the manufacturer of Telone II has suspended sales south and including Dixie, Gilchrist, Marion, Volusia and Flagler counties. This will result in no specific nematicide in these counties if carbofuran 15G is removed.

Illinois reports that 11% of the total acreage is untreated and that the only alternative would be repeated Sevin 50W applications that give poor control. Louisiana reports 79% of acreage untreated with no alternative to carbofuran on the acreage that is treated. Maryland also feels that no good alternative exists.

Missouri reports that oxamyl could replace carbofuran for nematode control and that repeated use of Sevin 50W could be a replacement for beetle control. However, both would result in higher application costs. Sevin control would not be that effective. These comments are identical to those made by New Jersey.

North Carolina has 45% of its acreage left untreated each year and where treatment is necessary they could rely on Telone II, oxamyl and ethoprop as alternative nematode control. Researchers in this state feel that good control could be afforded by any of these replacements. Additionally, they report that Telone II is the product of choice even with continued carbofuran availability.

Comparative Costs:

Of the materials available, carbofuran 15G at $0.53/oz. a.i. ranks 3 in terms of cost (Table 4). Telone II is the least expensive material at $0.06/oz. a.i. and Asana the most expensive at $8.59/oz. a.i. Vydate L is the best example in terms of moderate cost at $1.86. These cost ratios, however, change depending on the material when the cost of application is taken into account. The application cost reflected by the use of carbofuran ranges average around $25.00/acre depending on the state and method application. The use of Sevin, Asana or Lannate in Delaware would represent a cost of $9.00 to $12.00/acre depending on material 2 to 4 times a year for a total cost of between $18.00 to $48.00. For nematode control, replacements would range in terms of total cost between $31.58/acre for Telone II and $33.19/acre for Vydate L.

Table 4. Pesticide costs on per ounce a.i. basis

Active Ingredient	Brand Name	Unit	Price per Unit ($)	Price per oz. a.i. ($)
1,3-dichloropropene	Telone II	gal	10.40	0.06
carbaryl	Sevin 50W	lbs	11.39	1.42
carbofuran	Furadan 15G	lbs	1.27	0.53
	Furadan 4E	gal	51.50	0.80
esfenvalerate	Asana 1.9	gal	261.00	8.59
ethoprop	Mocap 15G	lbs	1.30	0.54
	Mocap 6EC	gal	50.00	0.52
methomyl	Lannate L	gal	35.00	1.22
oxamyl	Vydate L	gal	59.59	1.86

Use Impact Analysis:

The states most affected by the loss of carbofuran 15G would be, in order of importance, Illinois, Delaware, Ohio and Missouri. Least affected by the loss of carbofuran would be Florida and North Carolina. This, however, is in terms of current overall use patterns. States such as Louisiana report that there is no good alternative, loss of carbofuran in this case would have a great effect on 21% of Louisiana's total acreage. For beetle control, all states report moderate to good control with alternatives but have concerns regarding pollinator toxicity.

For the acreage treated for beetle control, all but Delaware report a yield loss of between 5 to 20% depending on the state and alternative. None of the states reporting suggest any decrease in quality due to the use of alternatives.

The total cash value of cucurbits, before production costs are accounted for, are estimated at $239,347,783.07 (Table 5). An average decrease in yield of 10% due to the unavailability of carbofuran would result in a monetary loss of $23,934,778.30.

Table 5. Cucurbit revenue estimates by state.

State	Crop	Total Yield (tons)	Price Per Ton ($)	Total Value ($)
Delaware	Cucumbers	6,600	150.00	990,000.00
	Melons	30,075	380.00	11,428,500.00
Florida	Cucumbers	70,392	365.24	25,709,974.08
	Melons	464,772	140.80	65,439,897.60
	Squash	62,808	544.29	34,186,027.58
Illinois	Cucumber	3,360	285.71	959,985.60
	Pumpkins	121,000	80.00	9,680,000.00
Louisiana	Melons	40,000	80.00	3,200,000.00
	Pumpkins	2,700	1600.00	4,320,000.00
Maryland	Cucumbers	31,500	150.00	4,725,000.00
	Melons	15,600	380.00	5,928,000.00
	Pumpkins	4,151	170.00	705,712.50
	Squash	2,665	340.00	906,100.00
Missouri	Cucumbers	1,840	285.71	525,706.40
	Melons	86,250	70.00	6,037,500.00
	Pumpkins	7,500	80.00	600,000.00
	Squash	1,000	200.00	200,000.00
New Jersey	Cucumbers	30,000	150.00	4,500,000.00
	Melons	30,075	380.00	11,428,500.00
	Pumpkins	3,000	170.00	510,000.00
	Squash	12,000	340.00	4,080,000.00
North Carolina	Cucumbers	36,399	293.33	10,677,044.61
	Melons	6,764	520.00	3,517,353.74
	Pumpkins	14,396	160.00	2,303,340.00
	Squash	23,169	352.38	8,164,336.96
Ohio	Cucumbers	47,250	185.00	8,741,250.00
	Melons	6,960	137.40	956,304.00
	Pumpkins	34,900	150.00	5,235,000.00
	Squash	12,690	325.00	4,124,250.00
	Total	**1,209,817**		**$239,347,783.07**

The states of Maryland, Michigan, New Jersey, Pennsylvania, Virginia, and West Virginia have a 24(c) label for the use of Furadan 15G and Furadan 4F on nonbearing peach and nectarine trees for nematode control. Individuals familiar with grower usage were contacted in each state.

In these six states, Furadan usage is <1% in Maryland, Michigan, Pennsylvania, and Virginia on nonbearing trees. In most instances where Furadan is utilized in these states, the 4F formulation is used. Thus, the vast majority of the economic assessment will be for the states of New Jersey and West Virginia.

All six of the states surveyed do recommend preplant and postplant nematicide applications. Preplant nematicide recommendations include soil fumigation or the use of nonfumigant nematicides. Postplant nematicide recommendations include only nonfumigant nematicides. The nonfumigant nematicides which are recommended/suggested include Furadan 15G, Furadan 4F, Nemacur 3SC and Vydate L. The nematicide usage in these states is provided in Table 1.

Table 1. Nonfumigant nematicide usage in nonbearing trees from states surveyed.

		Percent Acres Treated			
	Nonbearing	Furadan	Furadan	Nemacur	Vydate
State	**acres**	**15G**	**4F**	**3SC**	**L**
MI	1000	0	20	50	20
PA	1192	<1	<1	25	0
MD	450	<1	<1	25	5
VA	500	<1	<1	15	<1
WV	1000	30	30	40	0
NJ	2500	80	10	5	0

All states surveyed provide a nematode assay service to determine precisely when nematicide treatments are warranted. Grower utilization of this service varies from one state to the next. Nematicide applications, when employed, are used once a year in this region of the country.

Before presenting a detailed analysis of the economics of nematicide usage, a brief discussion of peach production is needed. Each fruit tree grown on a commercial farm is part of a grower's investment and potential income. The proper sized equipment and facilities are purchased to handle an anticipated volume of fruit. Any loss of trees or crop results in higher investment costs and, hence, higher unit production costs for the remaining fruit. These losses are real but are not easily calculated.

Peach trees are planted in rows at a specific spacing. The spacing, and hence density, is generally dependent on the soil type. The soils in most of the region surveyed have good water-holding and nutrient-holding capacity and planting density is generally about 100 trees/A. The soils in the outwash plains of New Jersey are relatively poor in nutrient-holding capacity and poor in water-holding capacity. Thus, tree growth is reduced and average tree density is about 110 trees/A in this area. For ease of calculations, all calculations are based on 100 trees/acre.

The varied planting densities are designed to ensure that the tree row will reach maximum density by the eighth growing season. This insures maximum productivity from the eighth year through the sixteenth year. Below is a chart depicting the anticipated yield/tree in a peach orchard in South Jersey.

Age	Yield (38 lb/boxes)
1st year	0
2nd year	0
3rd year	1
4th & 5th year	2
6th & 7th year	3
8th year and older	4

Yield data from other states would follow the same pattern. The planting densities employed result in a yield of about 400 boxes/A. Peaches growing in particularly favorable sites often produce 600-800 boxes/A, but this is well above average.

Peaches harvested in July command a lower price in most years than those harvested in August and September, $8.00/box versus $11.00/box. The grower's profit/box is approximately $2.70/box for July peaches and approximately $4.00/box for peaches harvested in August and September. Since 20% of the crop consists of July peaches and 80% of the crop consists of later peaches, the average profit for all peaches in a given year is about $3.75/box and the average price/box is $10.40.

Orchard establishment costs are encountered in any newly established orchard. If the trees die or become unproductive during the first four years of orchard life, the affected site is generally replanted. The cost of replacing a tree was established at $75.00/tree in 1982. The same figure is quoted today and is used in the economic analysis of this report.

Tree loss also results in a loss of crop for a specified number of years. Trees which are replaced after the first growing season require one additional season to produce their maximum 4 boxes. Thus, a crop loss of 4 boxes/tree results. Trees which are replaced after the second growing season require two additional years to produce a maximum crop and the loss is 8 boxes/tree. Trees replaced after the third year generally result in the loss of three crops, because the crop present on such trees during the final growing season is essentially nil.

A matter of greater concern is the effect on ecological matters, an area where economics is not well documented. Since

fertilizer and pesticide application equipment is designed to apply chemicals uniformly "down the row", any "missing tree" results in a site where chemicals are applied to areas which are not occupied by a crop plant.

The economic loss of such a situation to the grower, and eventually the consumer, is an increased unit cost for the remaining crop. The ecological effect, although probably not of major magnitude, has not really been determined; but it is an area of increasing concern.

Experimental equipment to address the problem of vacant planting sites is currently being developed. Until such time as this equipment is available commercially, maintaining orchards to prevent the loss of producing sites is both environmentally and economically a more sound approach.

Plant parasitic nematodes affect peach trees by reducing vigor and yield, by transmitting soil-borne virus diseases, and by providing sites for fungal invasion of the root system. The overall effect is less productive trees with smaller fruit and trees which die or become unthrifty and are removed.

Such trees are much more severely affected by environmental stresses. Drought stress results in a severe reduction in fruit size and weaker trees. Weaker trees are much more susceptible to winter injury which results in more direct tree loss, higher levels of Cytospora canker, and increased lesser peach tree borer problems.

All six states surveyed reported that tree loss during the first two years of establishment is a significant production problem. Maryland, Pennsylvania, Virginia and West Virginia report tree loss of about 2% for each of the first two years of orchard life where nematicidal treatments are not applied and 1% per year where treatments are applied. Tree loss in Michigan and New Jersey average 5%/year where treatments are not applied and 1%/year where nematicides are applied. Table 2 shows the number of trees treated with nonfumigant nematicides and Table 3 present the effect of treatment on tree loss.

The effect of Furadan 15G on reducing this loss varies between states, since the use of this material varies between these states. Furadan 15G is used extensively in New Jersey and West Virginia, and the nonfumigant nematicide use on one- and two-year old trees in these two states is provided in Table 2.

Table 2. Number of 1- and 2-yr-old trees treated with Furadan or Nemacur.

State	Total No. 1- & 2-yr-old	Number Nontreated	Number of trees treated Furadan 15G	Furadan 4F	Nemacur 38C
NJ	170,850	8,543	136.680	17,085	8,543
WV	87,000	0	26,100	26,100	34,800

Table 3. Tree loss with and without nematicide treatment in NJ and WV.

	Number of 1- & 2-yr-old trees lost							
	Nontreated		Furadan 15G		Furadan 4F		Nemacur 3SC	
State	Pot.*	Act.	Pot.*	Act.	Pot.*	Act.	Pot.*	Act.
NJ	427	427	6,834	1,368	854	171	427	86
WV	NA	NA	522	261	522	261	696	348

Pot. = Potential and Act. = Actual
*Based on 5% of trees lost in NJ and 2% tree loss in WV.

The increased cost from replanting trees when blocks require replanting is presented in Table 4A. The associated yield loss from trees which are removed and replanted is presented in Table 4C. Both tables represent data for situations where another nematicide is not utilized.

Table 4A. **Costs of replanting of 1- & 2-yr-old trees.**

	Furadan 15G		
State	Without	With	Difference
NJ	$512,550	$102,600	$409,950
WV	$ 39,150	$ 19,575	$ 19,575
Total	$552,700	$122,175	$429,525

Table 4B. **Costs of replanting of 1- & 2-yr-old trees.**

	Furadan 4F		
State	Without	With	Difference
NJ	$ 64,088	$ 12,818	$ 51,270
WV	$ 39,150	$ 19,575	$ 19,575
Total	$103,238	$ 32,393	$ 70,845

Table 4C. Yield losses from replanted 1- & 2-yr-old trees.*

State	Furadan 15G Without	With	Difference
NJ	$426,442	$ 85,362	$459,014
WV	$ 32,572	$ 16,288	$ 16,284
Total	$459,014	$101,650	$475,298

Table 4D. Yield losses from replanted 1- & 2-yr-old trees.*

State	Furadan 4F Without	With	Difference
NJ	$ 42,651	$ 8,531	$ 34,120
WV	$ 32,572	$ 16,288	$ 16,284
Total	$ 75,223	$ 24,819	$ 50,404

*1.5 crop/tree = 6 bu @ $10.40/bu

Furadan 15G is applied to the planting site only, and it is not applied to the spaces between trees. This results in a significantly lower quantity of ai applied per planted acre than if Furadan 4F or Nemacur 3SC is used.

Furadan 15G is applied in a 3-ft circle around the tree with 1-year-old trees and a 5-ft circle with 2-year-old trees (7.1 and 19.6 sq ft, respectively). Furadan 4F and Nemacur 3SC are applied in a 10-ft-wide band in the planting row. This procedure results in treatment of a 200-sq-ft area for each planting site. This relationship is presented in Table 5.

Table 5. Comparable nematicide rates when treating 1- & 2-yr-old peaches.

Material	Sq ft. treated	Formulated Rates Rt./tree	Rt./planted acre	Ai planted acre
Furadan 15G				
1 yr old	7.1	3.0 gm	10.58 oz	0.10 lb
2 yr old	19.6	8.2 gm	28.29 oz	0.27 lb
Furadan 4F				
1 & 2 yr old	200	0.88 fl oz.	0.69 gal	2.80 lb
Nemacur 3SC				
1 & 2 yr old	200	1.94 fl oz.	1.52 gal	4.56 lb

If Furadan 15G was removed from the market, approximately 85% of the acreage treated with this material would be treated with Furadan 4F, 10% would be treated with Nemacur 3SC, and 5% would be left untreated.

The overall effect on tree survival would be the same regardless of which nematicide was applied. The number of additional trees which would not be treated with a nematicide if Furadan 15G was unavailable would be 6834 trees in New Jersey and 1305 trees in West Virginia. With the 4% higher tree loss in New Jersey and the 1% higher tree loss in West Virginia where nematicides are not applied, the additional nonbearing tree loss in New Jersey would be 273 trees and the loss in West Virginia would be 13 trees. At an increased cost of $97.50/tree from replanting cost and yield loss, the increased yearly cost to nonbearing tree loss in New Jersey would be $26,618 and the loss in West Virginia would be $1268.

The trees which would not be treated if Furadan 15G were removed from the market would also suffer from a reduction in yield and orchard longevity. Although precise figures are not available for this loss, it has been estimated to represent 10% of the potential yield during the life of the orchard.

Assuming a yield of 50 bu/tree for the 18 years of the orchard's life, this would result in a yield loss of 341,700 boxes in New Jersey and 65,250 boxes in West Virginia. At an average profit of $3.75/box, the loss to New Jersey growers would be $1,281,375.00 and the loss to West Virginia growers would be $244,687.50 over the productive life of an orchard. This would result in a yearly loss of $71,187.50 for New Jersey growers and $13,593.75 for West Virginia growers.

A significant economic loss would be the increased cost of nematicide treatment if Furadan 15G were not available for grower use. The number of pounds of formulated product and the total cost for treatment with and without a label for Furadan 15G are presented in Tables 6A, B & C. The amount of nematicide used is adjusted for the increased number of acres which would be treated with other nematicides if Furadan 15G was not available for grower use.

The prices on which these data are calculated are as follows:

Chemical	Price per lb ai	Price per unit
Furadan 15C	$ 8.73 /lb	$ 1.31 /lb
Furadan 4F	$10.45 /lb	$41.80 /gal
Nemacur 3SC	$14.33 /lb	$42.99 /gal

Table 6A. Amount and cost of nematicides for 1- & 2-yr-old trees w & w/o Furadan 15G.

	<u>**Furadan 15G**</u>	
State	**Amount***	**Cost**
New Jersey:		
With 15G Label	1660.7 lb	$2175.52
Without 15G Label	0.0 lb	$ 0.00
West Virginia:		
With 15G Label	634.1 lb	$ 830.67
Without 15G Label	0.0 lb	$ 0.00
	<u>**Furadan 4F**</u>	
State	**Amount***	**Cost**
New Jersey:		
With 15G Label	117.9 gal	$ 4929.06
Without 15G Label	919.1 gal	$38418.63
West Virginia:		
With 15G Label	180.1 gal	$ 7528.01
Without 15G Label	323.6 gal	$13526.90
	<u>**Nemacur 3SC**</u>	
State	**Amount***	**Cost**
New Jersey:		
With 15G Label	129.9 gal	$ 5584.96
Without 15G Label	337.8 gal	$14522.63
West Virginia:		
With 15G Label	529.3 gal	$22754.61
Without 15G Label	568.8 gal	$24454.00

*Average rate for combined 1- & 2-year-old trees = 19.44 oz/acre.

The total quantity of nematicides in pounds of actual ingredient would increase considerably if Furadan 15G were no longer available for grower use. The total pounds of nematicide usage and increased quantity of use are presented in Table 7.

Table 7. Total quantity of nematicide usage w & w/o Furadan 15G.

State	With Furadan 15G	W/O Furadan 15G	Difference
NJ	1110.40 lbs ai	2663.00 lbs ai	1552.60 lbs ai
WV	2403.42 lbs ai	3012.80 lbs ai	609.38 lbs ai
Total	3513.82 lbs ai	5675.80 lbs ai	2161.98 lbs ai

SUMMARY:

Although nematicidal treatments are beneficial to peach and nectarine production in all states surveyed, the effect of nematicidal treatment on tree survival and productivity is apparently not dependent on the specific nematicide used. Of the six states surveyed, only growers from West Virginia and New Jersey use Furadan 15G to an appreciable extent.

The continued use of Furadan 15G by the peach and nectarine industry in New Jersey and West Virginia is important from an environmental and from an economic standpoint. If Furadan 15G were not available for grower use, an additional 1553 lb ai of nematicide would be use in New Jersey and an additional 609 lb ai of nematicide would be used in West Virginia.

The total cost of the nematicides used in New Jersey and West Virginia with Furadan 15G labelled for use is $12,689.54 and $31,086.29, respectively. If Furadan 15G was not permissible for grower use, the total cost for nematicide use in New Jersey and West Virginia would be $52,941.26 and $37,980.90, respectively. Thus, grower costs would be increased by $40,251.72 in New Jersey and by $6,894.61 in West Virginia.

An additional loss would be incurred by growers who lack suitable application equipment to apply other than Furadan 15G. This loss would occur principally to the "marginal growers" who can least afford any additional production expenses. The additional loss from the increased replanting costs and loss of yield of replants would be $4085.00/yr in New Jersey and $764.00/yr in West Virginia. The increased yearly loss from lower productivity in bearing blocks which did not receive a nematicide treatment would be $71,187.50 for New Jersey growers and $13,593.75 for West Virginia growers.

The increased loss from replanting costs when Furadan 15G is not applied totals $429,525 for New Jersey and West Virginia growers. Comparable figures for yield loss for the two states would be $475,298. However, this loss would not occur if substitute nematicides were utilized.

Thus, the economic impact of removing Furadan 15G from the marketplace while retaining Furadan 4F and Nemacur 3SC use patterns would be as follows:

	New Jersey	West Virginia
Increased nematicide cost	$ 40,252	$ 6,895
Increased replant cost	4,085	764
Yield loss	71,1881	3,594
Total	$115,525	$21,253

RICE

Rice is grown in the United States in Arkansas, California, Florida, Louisiana, Mississippi, Missouri, and Texas with an average yearly rice production, based on information from 1980 through 1988, of approximately 142,000,000 cwt (see attached map). The annual value of U.S. rice production during this time period was roughly $1.2 billion. Using a multiplier factor of 3.2, the yearly impact of rice farming on the U.S. economy is approximately $4.4 billion. For comparison, the value of U.S. corn, soybean and winter wheat production in 1988 was roughly $13 billion, $12.8 billion and $323 million, respectively. On a global scale, U.S. rice acreage is only 0.9% of the world total, however, American rice farmers produce 1.7% of the world's rice. Most American rice (about 60%) is exported, often making the U.S. the largest exporter of rice in the world. Therefore, U.S. rice plays a crucial role in feeding the world when food stocks are low due to droughts, untimely flooding, or other catastrophic events.

Rice production in America is highly mechanized and sophisticated -- only seven man-hours are required to produce one acre of rice in the U.S. while more than 300 man- hours are needed in Asia and Africa. In the U.S. land is tilled with large tractors equipped with plows, discs, and harrows; divided into basins surrounded by levees to impound water and facilitate irrigation; and planted by air or large tractor drawn seeders. Rice is fertilized and treated by air with pesticides and harvested with self propelled combines. Active research and extension programs exist in all the rice producing states. These programs are funded by producer, industry, state, and federal contributions. Research is aimed at increasing yields, decreasing production inputs, improving quality, decreasing environmental problems associated with rice production, and improving marketing of the commodity.

A complex of insect pests attack U.S. rice from planting to post-harvest with the rice water weevil (RWW), Lissorhoptrus oryzophilus Kuschel, being a key pest. Adults invade rice fields in the spring and lay eggs in rice stems underwater. Eggs hatch and larvae move to roots where feeding results in delay in maturity and reduction in tillers and yield. The only insecticide labeled for use on rice to control the RWW in the United States is carbofuran. The remainder of this report constitutes a benefits assessment of carbofuran's use on rice in the U.S. The report will follow sections IV, V, and VI of the U.S.D.A.'s Outline for Pesticide Use Benefits Assessment.

IV. Specific Use Analyses

A. Current Registered Uses of the Pesticide by Site/Commodity

1. Registration summary

Carbofuran is applied as granular formulations to control the RWW. In the southern rice producing states (Arkansas, Louisiana, Mississippi, Missouri, and Texas), Furadan 3G and Furadan 5G are labeled and applied at 15 to 20 lb/ac (0.45-0.60 lb ai/ac) and 10 lb/ac (0.50 lb ai/ac), respectively, from one day before or within 21 days after permanent flooding (see

attached specimen label). In the south, most rice fields are dry seeded in the spring. If there is sufficient soil moisture, the seeds germinate and rice seedlings emerge through the soil, however, when soil is too dry at planting, the field is flooded and drained which is called a "flush" irrigation. Occasionally, rainfall occurs at the proper time and substitutes for a flush. Additional flushes are applied when needed until rice is in the four to five leaf or actively tillering stage, approximately four weeks after seeding. At this time a flood is applied and maintained until rice nears maturity. This is called a "permanent" flood. In addition, some rice fields in the south are flooded then water seeded. These fields are drained for a brief or extended period before the permanent flood is applied, or are not drained making the initial flood a permanent one. These flooding methods are called "prolonged drainage", "pinpoint flood", and "continuous flood", respectively.

In California, Furadan 5G is labeled and applied at 10 lb/ac (0.50 lb ai/ac) prior to flooding and planting (see attached specimen label). Thus, California fields are water seeded with the initial flood maintained until near harvest.

<u>Flooding practices affect RWW population dynamics and timing of carbofuran applications.</u>

Although rice is grown in Florida, carbofuran is not labeled or used for RWW control because of minimal weevil problems and an alternative method of control which will be discussed in IVB.

2. Pest damage and infestation information

Planting and flooding date, rice variety and stand, water depth, fertility, edaphic factors, weather, method of irrigation and field design have a profound influence on RWW population dynamics and damage to rice. Obviously, these modifying factors vary within and among rice producing states; thus, yield losses due to the RWW will also vary within and among states. However, the RWW is the most ubiquitous insect pest of rice in the United States. Rice entomologists have not observed a single rice field that was not infested to some extent by the RWW. In fact, the aldrin seed treatment that was used prior to the registration of carbofuran was applied to 90% of the rice acreage in the southern rice producing states to control this pest.

Estimates of average yield reduction due to the RWW are based on field experiments with RWW protected and unprotected plots, and expert opinion of county extension agents, farm advisors, extension specialists, and university and USDA researchers familiar with rice production. These estimated average yield losses are assumed to occur given the withdrawal of carbofuran from use on rice acreage to be treated with this insecticide. However, entomologists from Louisiana and Texas estimate that in general twice as much rice acreage in these states should be treated for the RWW than is currently being treated. Sampling for the RWW is time consuming and requires some expertise; thus many producers do not sample and remain unaware of the extent of damage and opt not to treat fields which are infested. Also, some producers, in a mistaken effort to save money, do not use carbofuran even though RWW populations justify

an application. Finally, average yields by state are taken from carbofuran treated and untreated acreage. Thus, these yields should be lower relative to those from only carbofuran treated acreage. This results in a lower total production loss per state due to the RWW. For these reasons and the conservative figures of the surveyed experts, estimates of yield loss by the RWW are considered low.

Arkansas - Average yield loss on carbofuran treated rice acreage given withdrawal of the insecticide was estimated at 10%.

California - Average yield loss on carbofuran treated rice acreage given withdrawal of the insecticide was estimated at 33% (65-69). Untreated experimental plots have shown losses in yield ranging from 10 to 95% when compared to treated plots.

Louisiana - Average yield loss on carbofuran treated rice acreage given withdrawal of the insecticide was estimated at 10% An average of between 425-500 lb/ac decrease in yield was also estimated. However, in years of heavy infestation, 50% loss in yield can occur.

Mississippi - Average yield loss on carbofuran treated rice acreage given withdrawal of the insecticide was estimated at 900 lb/ac or about 18%.

Missouri - Average yield loss on carbofuran treated rice acreage given withdrawal of the insecticide was estimated at 15%.

Texas - Average yield loss on carbofuran treated rice acreage given withdrawal of the insecticide was estimated at 10%. Yield losses of the main crop have been reported as high as 30%. Unpublished data also show that RWW damage to the main crop can reduce yield of the ratoon crop which develops from main crop stubble. The ratoon crop is becoming increasingly important in Texas and Louisiana; in Texas approximately 40% of the main crop is ratooned.

The estimates show that average yield losses in California are about twice those of the majority of southern states. Major differences in rice culture, varieties, and RWW biology occur in California. Because rice emerges through a continuous flood in California, plants are attacked earlier and are weaker at time of attack. All RWWs are parthenogenetic females in California and show a distinct preference for rice growing near the levees and margins of fields. Most rice in the south does not receive a permanent flood until plants are actively tillering when they are more vigorous and less vulnerable to RWW attack. Both males and females occur and injury is more widespread across the fields; however, field margins still tend to harbor higher populations.

3. Pest management recommendations

Economic thresholds and recommendations have been established for the RWW and are published and utilized by producers and consultants throughout the rice growing states. The following is a state by state summary of the recommendations.

Arkansas - Two sampling methods can be used to estimate RWW activity. One is based on larval populations which are sampled

14 days after the onset of the permanent flood by removing soil cores (each core is 4 in. diam. by 3 in. deep) containing plants. A carbofuran treatment is economically justified if 10 or more larvae per core are recovered. A second method is based on adult feeding scars found on the youngest leaf of rice plants seven days after onset of the permanent flood. A sequential sampling plan is available which identifies levels of adult feeding activity and corresponding decisions to not treat or treat with carbofuran.

California - Recommendations are based on field history. Preventive preplant, preflood treatments of carbofuran should be applied to fields with chronic histories of damaging RWW populations. Only areas adjacent to field margins and levees should be treated. In fields with no history of RWW damage, postflood sampling for adult feeding scars is advised. Sampling should occur four to seven or 11 to 14 days after rice emergence through the water. For the earlier sampling period, if 20% of the plants have at least one adult feeding scar on the newest, unfurled leaf, then the field should be drained and treated. The threshold for the later sampling period is 10%.

Louisiana - Treatment decisions are based on adult feeding scars or larval densities. Rice should be sampled for feeding scars three to five days after the permanent flood in dry-seeded fields or an equal time after plants emerge through the water in water- seeded fields. Basically, fields should be treated if 50% or more of the sampled plants have a scar(s) on the newest, unfurled leaf. Larvae should be sampled seven to 10 days after the permanent flood in dry-seeded fields or an equal time after plants emerge through the water in water-seeded fields. If an average of five or more larvae are recovered per soil core, a carbofuran treatment is advised.

Mississippi - Larvae are sampled when adult feeding scars appear. A treatment is recommended when at least an average of one larva per core is recovered.

Missouri - Recommendations follow those developed for Arkansas.

Texas - Recommendations are similar to those of Louisiana.

4. Actual on-farm use data

All of the following estimates are based on information from 1983 through 1988.

Arkansas - An average of 1,067,500 ac was planted in rice and a mean of 3.7% (range 1-5%) of that acreage was treated annually with carbofuran. An FMC estimate of treated acreage was much higher for 1983 but the lower estimate was chosen to maintain a conservative approach to the study. California - An average of 390,167 ac was planted in rice and a mean of 30% (range 24.6-34.4%) of that acreage was treated annually with carbofuran.

Louisiana - An average of 456,667 ac was planted in rice and a mean of 30% of that acreage was treated annually with

carbofuran.

Mississippi - An average of 196,167 ac was planted in rice and a mean of 33% (range 16-50%) of that acreage was treated annually with carbofuran.

Missouri - An average of 71,167 ac was planted in rice and a mean of 5% of that acreage was treated annually with carbofuran.

Texas - An average of 336,333 ac was planted in rice and a mean of 30% of that acreage was treated annually with carbofuran.

For all states, only one application of carbofuran per growing season is allowed. In California, only 0.50 lb ai/ac can be applied, however, in the remaining states, 0.45-0.60 lb ai/ac can be applied. Some Louisiana and Texas rice producers who water seed use the high rate of carbofuran but the majority use 0.50 lb ai/ac.

5. Crop systems and practices

Arkansas - Carbofuran applications are generally made by air from one day before to 14 days after onset of the permanent flood. Rice is actively tillering at this time and approaching panicle initiation. Other crops grown in the rice producing counties include cotton, soybeans, grain sorghum, corn, catfish and baitfish. Rice and soybeans are often rotated in an effort to control red rice, a major weed pest of rice, and certain diseases. No problems involving drift of carbofuran into catfish and baitfish ponds have been reported.

California - Virtually all applications of carbofuran are made prior to flooding on dry soil at the time rice is planted. Most applications are made by air but some acreage is treated by ground. Almonds, plums, safflower, sunflowers, tomatoes, wheat, barley, walnuts, sugar beets, asparagus, cherries, peaches, cattle, kiwi, squash and melons are some of the other commodities produced in the rice growing counties. Despite this diversity, rice acreage is generally not planted to other crops.

Soil incorporation of carbofuran granules in the first two basins to receive water is required before flooding carbofuran treated fields. Also, producers strive to create a cloddy seed bed to minimize seedling drift. When carbofuran is applied to this type of seed bed, not all of the insecticide remains on the soil surface. These practices reduce non-target exposure to carbofuran.

Louisiana - Carbofuran is applied from one day before to 21 days after the onset of the permanent flood when rice is actively tillering. Most is applied by air between 10 and 14 days after the permanent flood in dry- seeded fields and at plant emergence through the water in water-seeded fields. Soybeans, crayfish, cattle, wheat, cotton, corn, and grain sorghum are the other major commodities grown in the rice producing parishes. Rice and soybeans are commonly rotated. About 100,000 ac of crayfish ponds occur in the rice producing counties. Most crayfish farms are double cropped with rice but the majority of this acreage is not treated with carbofuran.

Mississippi - Carbofuran is applied by air usually between one and two weeks after the onset of the permanent flood when rice is actively tillering. Soybeans, cotton, grain sorghum, and catfish also are grown in the rice producing counties with rice and soybeans commonly rotated. Rice and catfish farmers are acutely aware of the potential problem of carbofuran use near catfish ponds, thus, carbofuran is not applied to rice adjacent to these ponds and no problems have been reported.

Missouri - Most applications of carbofuran are made by air about 10 days after the onset of the permanent flood when rice is actively tillering. Other commodities grown in the rice producing counties are soybeans, corn, wheat, cotton, and catfish. Soybeans and rice are commonly rotated. No problems involving carbofuran use on rice and catfish production have been reported.

Texas - Carbofuran is applied by air usually seven to 14 days after the onset of the permanent flood when rice is actively tillering. Soybeans, cattle, sorghum, cotton, turf, corn, and crayfish are other commodities grown in the rice producing counties. Soybeans are normally rotated with rice to help control red rice and certain diseases.

In all states, water from carbofuran treated rice acreage is impounded to prevent movement into untreated areas (drainage ditches, canals, rivers, bayous, bays, marshes, and larger bodies of water). This practice probably also increases the effectiveness of the chemical treatment.

As described in IVA3, RWW control guidelines based on economic thresholds are available in all rice producing states where carbofuran is labeled. Use of these guidelines minimizes pesticide misuse and maximizes the effectiveness of the compound. Because the margin of profit in U.S. rice farming is becoming smaller, producers are becoming better crop managers and are employing extension and university recommendations to a greater extent than in the past. This trend should continue as U.S. rice farming becomes more technological and competitive with foreign rice suppliers.

6. Potential for pest resistance

Carbofuran has been labeled and applied to U.S. rice since 1970 (Furadan 3G registered January 23, 1970 in southern rice producing states; Furadan 5G registered August 7, 1972 in California) and to date no evidence of RWW resistance to carbofuran has been reported. However, in 1958 aldrin seed treatments were recommended for RWW control in Texas and by 1966 populations had developed resistance to this chlorinated hydrocarbon. RWW resistance to aldrin was reported as early as 1965 in Arkansas; thus, the RWW probably has the potential to become resistant to carbofuran. Since only female RWWs occur in California, resistance, if it develops, would be expected to occur sooner in the southern rice producing states which harbor more highly, genetically variable populations composed of males and females. On the other hand, the low number of RWW generations produced per year (one in California and Arkansas and two in the remaining rice producing states), the practice of applying one treatment of carbofuran annually, the relatively small amount of

total rice acreage treated with carbofuran, and the wide host range of the insect should discourage development of resistance.

B. Alternative management practices by site/commodity

Carbofuran is the only insecticide labeled on U.S. rice for RWW control. Entomologists in Arkansas, California, Louisiana, and Texas have evaluated the efficacy of pesticides for RWW control for many years. After the RWW developed resistance to aldrin, which was subsequently banned by EPA, an intensified screening program began resulting in the registration of carbofuran and bufencarb granules. The granular formulations were chosen to reduce the possibility of drift which had been a previous problem in rice fields. Bufencarb was dropped by the parent company because of reduced efficacy in controlling corn rootworms in the Midwest. The termination report of Regional Project S-162: Biology and Management of Insect Pests of Rice in the U.S. summarized U.S. rice entomologists' work on screening insecticides for RWW control with the following statement. "Over the duration of the project 43 insecticides were evaluated for rice water weevil control. The efficacy, rate, and timing of application was established for the insect growth regulators Dimilin and Alsystin, the synthetic pyrethriods Ambush, Pounce, Cymbush, Ammo, and PP-993, and the organophosphates Amaze, Counter and SC-0567 when used for rice water weevil control." For more detailed information, see the Annual Progress Reports of the Louisiana Agricultural Experiment Station Rice Research Station, Proceedings of the Rice Technical Working Group, and Insecticide and Acaricide Tests from 1981 to 1988. The granular formulations of carbofuran have been used as the standard of comparison in these efficacy tests with the result that Furadan 3G and 5G consistently gave as good or better control than the tested insecticides.

Because the RWW is aquatic in several stages, the management of water is a logical tool for manipulating its populations. In Florida, rice was grown on approximately 14,000 ac in 1988. The soil is very high in organic matter and rice producers commonly drain fields which releases nitrogen to the crop. In so doing, RWW populations are controlled and carbofuran is not needed. However, in the future, rice acreage will probably expand to include mineral soils which may require applications of insecticide for RWW control. In Arkansas, draining rice fields about two weeks after the onset of the permanent flood helps control straighthead (a physiological disorder of rice) and the RWW; however, carbofuran treatments aimed at the RWW are usually more economical because of reflooding costs, loss of nitrogen, weed reinfestation, and increased mosquito problems associated with draining. In all other rice producing states draining is not recommended as a tactic for controlling the RWW. During the summer months in the south, frequent rainfall occurs which prevents rice fields from drying sufficiently to reduce RWW populations. In California, summer rains seldom occur and would not hinder a draining program to control the RWW. However, herbicide residues in drain water are a serious legal problem in California. In addition, water delivery systems sophisticated enough to prevent excessive drying could be a problem in California where many rice fields are precision leveled resulting in very large basins. Draining is a potential management tool but there is a delicate balance between the benefits of RWW

population reduction and the disadvantages of plant water stress and competition with weeds.

Most stages of the RWW are concealed from attack by biological control agents. The egg is inserted in plant tissue underwater, and the larval and pupal stages are passed on rice roots surrounded by water-saturated soil. U.S. rice entomologists are not aware of natural parasites of the immature stages and predation of these stages is at most occasional and fortuitous. Recent tests with the nematodes Steinernema carpocapsae and Heterorhabditis sp. have shown promise when applied to moist soil as an inundative release for control of immature RWWs. Future work will emphasize timing of application and cost effectiveness. The adult RWW is subject to occasional but minimal predation in the aquatic habitat. Rodents consume some overwintering adults and a species of Beauveria fungus was recovered from weevils removed during winter from the crowns of perennial grass clumps. An undescribed species of mermithid nematode was found to parasitize RWW adults in Arkansas. The nematode caused adult mortality, infected primarily females, and decreased their fecundity. The maximum infection rate of adult weevils collected periodically in rice fields was 5.4%. To date, biological control agents do not offer a satisfactory substitute for existing chemical control.

The RWW overwinters at the bases of various weedy vegetation and plant debris on rice field levees and ditch banks. Some producers believe that destroying the overwintering sites will control the RWW. However, this would require a widespread cooperative grower effort and if implemented may not prove effective. A major drawback of the proposed control tactic would be elimination of cover for prime nesting areas for wildlife species such as pheasant, dove and resident ducks.

An ideal solution to the RWW problem would be to develop a resistant/tolerant variety. Efforts have been directed towards the plant resistance goal since 1963. In California, the sources of tolerance tend to be leafy, intermediate in height, and susceptible to lodging and blanking. Selections are being made to eliminate these undesirable traits, but given the release of a tolerant cultivar, the need for chemical control would still be required because of the relatively low levels of tolerance present in parental genotypes.

IVC. Economic and social impacts by site/commodity

The following production figures were taken from Agricultural Statistics U.S.D.A. Handbooks with the exception of some 1988 estimates which were provided by surveyed rice experts. Rough rice prices were from the same source and averages were by state for 1983, 1984, and 1985; average U.S. price for 1986 and 1987; and state estimates for 1988 which were provided by the same rice experts as cited above. The price base includes allowances for loans outstanding and purchases by the government valued at the average loan and purchase rate. Cost of carbofuran applications were based on estimates for 1989 provided by rice experts cited above and various aircraft applicators.

Arkansas - Average yield is 49.97 cwt/ac, average price of $6.75/cwt and total cost of carbofuran treatment is $15.00/ac.

California - Average yield is 72.26 cwt/ac, average price is $5.73/cwt, and total cost of carbofuran treatment is $13.42/ac.

Louisiana - Average yield is 43.40 cwt/ac, average price is $7.31/cwt, and total cost of carbofuran treatment is $12.00/ac.

Mississippi - Average yield is 49.17 cwt/ac, average price is $7.51/cwt, and total cost of carbofuran treatment is $12.00/ac.

Missouri - Average yield is 49.70 cwt/ac, average price is $7.46/cwt, and total cost of carbofuran treatment is $12.00/ac.

Texas - Average yield is 54.70 cwt/ac, average price is $7.63/cwt, and total cost of carbofuran treatment is $12.00/ac.

Table 1 summarizes the pertinent information needed for an economic assessment of the benefits of carbofuran to U.S. rice producers. Basically, for each state, yield loss/ac due to the RWW was converted to production loss in $/ac from which the cost/ac of a carbofuran treatment was subtracted. This value is considered the net benefit in $/ac from a carbofuran treatment. Finally, the net benefit/ac is multiplied by the number of carbofuran treated acres to arrive at the total net benefit for each state due to carbofuran.

Since the production estimates are based on six year averages and recent trends are towards increased acreage, yield and price, the total annual benefit for U.S. rice producers of $24.5 million due to carbofuran is obviously low. In addition, if government deficiency payments are taken into account, the economic benefits of carbofuran use are much greater because the target price of rice is employed in the calculations. The average target price for rice between 1983 and 1989 was $11.53/cwt. Using this figure, the following state by state net benefits of carbofuran use are:

State	**Annual net benefits (\$\ac) of carbofuran**	**Annual total net benefits (\$/state of carbofuran)**
AR	42.62	1,683,383
CA	261.52	30,610,942
LA	38.04	5,211,484
MO	73.96	263,176
MS	90.05	5,829,397
TX	51.07	5,152,958
Total		48,751,340

V. Exposure Considerations

The trigger for the special review of granular carbofuran is problems with avian toxicity. Rice fields provide excellent habitat for many species of vertebrates, including birds. In fact, many farmers lease their rice acreage for hunting purposes

during the late fall and winter when the land is idle. However, none of the surveyed rice researchers and extension specialists in the southern states was aware of any bird kills associated with the legal use of carbofuran on rice with the exception of a single report from Texas. In this study by Flickinger et al. three western sandpipers, one pectoral sandpiper and two redwinged blackbirds were found dead following application of carbofuran to five flooded rice fields on the Texas Gulf Coast. However, no mortality occurred when fulvous whistling ducks and mallard ducks were placed in cages in carbofuran treated rice fields. The authors of the report state: "The carbofuran levels in rice field waters from Furadan 3G applied at 19 kg of granules/ha (0.5 lb ai/ac) would not be expected to result in significant losses of either species" (fulvous whistling duck and mallard). They conclude that to minimize exposure of birds to 3G Furadan, the insecticide should only be used when insect density or damage is sufficiently high to warrant treatment. As mentioned before, economic thresholds for the RWW are available and used by U.S. rice producers and consultants. Basically, use of the thresholds forces producers to treat only when damaging RWW populations are present. This minimizes exposure of birds to carbofuran. The report further recommends that carbofuran should be applied to rice after May 15 to avoid the peak of bird migration. In the southern rice producing states, most carbofuran is applied one to two weeks after the onset of the permanent flood which generally occurs in May and June. In southwest Louisiana less than 5% of the carbofuran for RWW control is applied before May 15. Also, in the south, carbofuran is generally applied to flood water (not on exposed soil) so granules are not as accessible to birds. The granules sink into the mud substrate where the weevil larvae occur. Attached are copies of letters from three wildlife biologists from Louisiana and Arkansas with supporting evidence that carbofuran, when used legally on rice, poses little threat to birds.

Waterfowl mortality in California rice fields treated with carbofuran was summarized in 1988 by Littrell. The bird kill was 630 from 1984 through 1988 with 105 deaths (104 ducks and one shorebird) occurring in the spring when Furadan 5G was applied for RWW control. The breakdown of deaths by years was 51, 31, 12, 3, and 0 from 1984 through 1988, respectively. The birds most likely contacted the granules through dabbling activities as fields were flooded following the preplant application of the insecticide. Littrell also reports bird mortality from carbofuran granules in the fall of 1985 (203 waterfowl and one northern barrier), fall of 1986 (218 waterfowl and four red-tailed hawks), and winter of 1988 (50 ducks). He did not identify the source of carbofuran causing mortality in the fall and winter and stated that literature did not support the theory that carbofuran persisted in rice fields for up to eight months from legal spring application.

Carbofuran has been misused with detrimental effects on birds. For instance, Flickinger et al. reported that Flowable Furadan was being used in Texas as a seed treatment to kill blackbirds depredating on the rice crop. Investigations conducted in 1984 to 1986 by the United States Fish and Wildlife Service resulted in the prosecution of parties involved in these illegal actions. American Rice Growers Cooperative in Raywood, Texas was fined $10,000 in a plea agreement involving 18 to 20

rice producers. Matagorda Farmers Cooperative in Bay City, Texas was fined $2,500 in a similar plea agreement. These were very strong warnings and have halted the illegal use of carbofuran in Texas.

Recent fall and winter duck kills in California in 1988 may have been associated with the illegal use of carbofuran to kill crayfish (which burrow into levees) to prevent loss of water from basins flooded to attract waterfowl for hunting. Accidental spillage and failure to clean up may also be responsible for some of the reported bird kills in California. In one such instance a field with a temporary airstrip used in the application of agrichemicals was fallowed in 1987 and planted with rice in 1988. Carbofuran residues from spillage on the airstrip may have been responsible for subsequent bird kills in 1988.

Procedures to reduce or eliminate bird kills are in practice or being studied. As mentioned before, soil incorporation of carbofuran granules in the first two basins of treated fields is now required in California. This appears to be a successful tactic because of reduced resident duck kills in 1987 and failure to detect any kills in 1988 despite extensive air and ground surveys. A regulation to coat airstrips with asphalt to facilitate cleanup and discourage flooding is being considered. Littrell states: "Work continues to eliminate the deleterious effect of carbofuran. Cultural methods involving incorporation of granules into the soil prior to flooding has shown great promise with respect to lowering or eliminating the incidents of waterfowl loss. Use or modification of this application practice or development of other methods to prevent losses will continue until there is assurance that no waterfowl will be lost as a result of normal rice cultural practices using carbofuran. Enforcement activities will continue as a measure to prevent the possible illegal use of carbofuran during the fall months."

VI. Conclusion and Recommendations

Rice is grown in seven states in the U.S. on over 2.5 million acres which are perennially infested with the RWW -- the nation's most damaging insect pest of rice. **Data from replicated experiments and conservative estimates of experts attribute a national, annual rice production loss of 14% on RWW infested acreage.**

Carbofuran is the only insecticide labeled for control of the RWW, although during the past eight years over 40 insecticide treatments have been evaluated by State Experiment Station and USDA entomologists. Most treatments were not as consistently effective as carbofuran and the few that showed promise were dismissed by the parent companies for reasons other than problems of efficacy. **Depending on the price of rice received by producers, the annual benefit of carbofuran to U.S. rice farmers is estimated between $24.5 million and $48.7 million.**

Currently, no viable alternatives to carbofuran exist despite extensive research efforts in searching for other control tactics involving manipulation of irrigation practices and planting dates, development of resistant varieties, identification and impact of natural biological control agents,

and determination of weak links in the life history of the RWW.

Carbofuran use in rice poses a minimal threat to non-target species including birds. All carbofuran is applied in granular formulations which reduces the possibility of drift and allows more of the insecticide to reach the target site. In the southern rice producing states, most carbofuran is applied to flooded fields after migratory waterfowl have moved north. In California, recent regulations require incorporation of the granules in the first two water receiving basins of each treated field. In addition, all rice producing states have guidelines for control of the RWW based on economic thresholds which optimize the use of the insecticide. Many rice producers employ these recommendations in an effort to decrease production costs and increase yield.

Carbofuran has been applied illegally to kill blackbirds depredating on sprouting and ripening rice but prosecution of guilty parties has had the desired effect of eliminating this abuse. The insecticide has also been misused in California for control of crayfish which burrow into levees and cause drainage of basins. However, at present, investigations are being conducted by U.S. Fish and Wildlife Service to end this practice.

In conclusion, carbofuran is an excellent pest management tool for U.S. rice producers. When used according to label instructions, this insecticide is relatively safe to non-target wildlife species associated with the rice agroecosystem. The withdrawal of carbofuran would significantly reduce rice production and income to producers, since no viable alternative controls for the RWW are available. For these reasons, carbofuran should be retained for RWW control in U.S. rice production.

Table 1. Economic assessment of the benefits of carbofuran for control of the rice water weevil (RWW) on rice in the U.S.

(1)	State	AR	CA	LA	MO	MS	TX	TOTAL
(2)	Formulation	Furadan 3G	Furadan	Furadan 3G	Furadan 3G	Furadan 3G	Furadan 3G	
(3)	Avg rice ac planted	1,067,500	390,167	456,667	71,167	196,167	336,333	
(4)	Avg price rice ($/cwt)	6.75	5.73	7.31	7.46	7.51	7.63	
(5)	% acres treated	3.7	30	30	5	33	30	
(6)	Avg yield (cwt/ac)	49.97	72.26	43.40	49.70	49.17	54.70	
(7)	Avg a.i./ac	0.5	0.5	0.5	0.5	0.5	0.5	
(8)	No application/yr	1	1	1	1	1	1	
(9)	Total cost ($) of treatment/ac (includes insecticide plus application cost)	15.00	13.42	12.00	12.00	12.00	12.00	
(10)	Quality loss due to RWW	0	0	0	0	0	0	
(11)	Avg yield loss (%) due to RWW	10	33	10	15	13	10	
(12)	Net benefit ($/ac) from carbofuran[a]	18.73	123.22	19.73	43.61	54.47	29.74	
(13)	Total net benefit ($)/state from carbofuran[b]	739,788	14,422,913	2,703,012	155,180	3,526,121	3,000,763	24,547,777

[a] Row 12 was derived by: [(6) x (11)/100 x (4)] – (9).

[b] Row 13 was derived by: (12) x (3) x (5)/100.

Furadan 15G (carbofuran) is registered for thrips and leafhopper control on peanuts at up to 1.0 lb. ai/acre. For control of Southern Corn Rootworm (SCR) in the southeastern states, Furadan 15G is registered for use at 1.0 to 2.0 lb. ai/acre banded over the row at pegging (60-90 days after planting).

Furadan is labeled up to 4.95 lb. ai/acre for nematode control to be applied in an 18 inch band prior to planting and incorporated to a depth of 3 inches.

Furadan 15G is applied for thrips control on 18,468 acres of the 1.57 million acres of peanuts planted in the United States. Numerous studies from all peanut areas of the United States indicate that thrips control seldom results in increased yield. Therefore, no quality or yield adjustment can be attributed to thrips damage when any of these insecticides are lost. Furadan's lack of effectiveness in controlling thrips appears to be the primary reason for its relatively small usage compared to the other insecticides.

Southern Corn Rootworm is a soil insect that damages peanuts by feeding on pegs or pods. Significant population of SCR are found in Georgia, Virginia, North Carolina, and South Carolina. Only occasionally are SCR a problem in Alabama or Florida.

Although most research data shows carbofuran efficacy on SCR in peanuts to be similar to the alternatives, Furadan 15G is only used on about 31 thousand acres of the 293 thousand acres treated for SCR. No loss of benefit can be shown when carbofuran alternatives are used.

Seven and one-half percent (117,750 acres) of the United States peanut acreage is treated with carbofuran ostensibly as a nematicide (i.e. banded at high rates). It is possible, however, that some of the reported insecticide treated acres are redundant with nematicide treated acres reported, since some growers use this material for both purposes in one application. Only one state reported a quality change (Oklahoma) and one state reported a yield change (Virginia) resulting from the loss of carbofuran. In general, there are currently adequate alternative materials available and little economic impact would result from the loss of carbofuran as a nematicide.

Although the committee is hesitant to see an available granular pesticide alternative removed, the small amount used and marginal benefit indicates that the loss of carbofuran will not burden peanut producers.

FURADAN ASSESSMENT

Crop: Peanuts
Pest: Thrips

State	Total Acres Treated w/all insecticides	% Total Treated of Planted	Total Acres Treated w/Furadan
Alabama	197,280	90	1,973
Florida	71,040	80	710
Georgia	387,960	60	0
North Carolina	121,920	80	0
South Carolina	11,880	90	713
Virginia	91,336	98	0
Texas	122,300	50	1,223
Oklahoma	57,480	60	13,795
New Mexico	6,560	50	0
Mississippi	5,381	99	54
Total	1073,137	68	18,468

FURADAN ASSESSMENT

Crop: Peanuts
Pest: Southern Corn Rootworm

State	Total Acres Treated All Insecticides	Treated % of Planted[Y]	Total Acres Treated w/ Furadan
Alabama	0	0	0
Florida	0	0	0
Georgia	116,388	18	18,622
North Carolina	106,680	70	7,468
South Carolina	4,620	35	1,617
Virginia	65,240	70	3,262
Texas	0	0	0
Oklahoma	0	0	0
New Mexico	0	0	0
Mississippi	0	0	0
Total	292,928	24.0	30,969

Y note- Furadan only labeled in S.E. states for SCR.

FURADAN ASSESSMENT

Crop: Peanuts
Pest: Nematodes

State	Total Acres Treated w/all nematicides	Total Treated % of Planted	Total Acres Treated w/Furadan
Alabama	76,650	35	0
Florida	66,750	75	0
Georgia	135,996	21	6,800
North Carolina	21,641	14	216
South Carolina	1,650	13	132
Virginia	69,900	75	32,154
Texas	29,352	12	2,348
Oklahoma	9,580	10	7,664
New Mexico	0	--	0
Mississippi	160	4	2
Total	411,679	--	49,316

CARBOFURAN - PEANUT STATISTICS

State	Planted* Acreage	Production* Avg. Yield/A	Avg. Annual $ Value Prod. Total	$ Avg. Per Acre
Alabama	219,200	2547	150,741,640.00	687.69
Florida	88,800	2836	67,995,936.00	765.72
Georgia	646,600	2844	496,511,200.00	767.88
South Carolina	13,200	2494	8,888,616.00	673.38
North Carolina	152,400	2863	117,806,720.00	773.01
Virginia	93,200	2907	73,151,748.00	784.89
Texas	244,600	1708	112,799,730.00	461.16
Oklahoma	95,800	2171	56,155,086.00	586.17
New Mexico	13,120	2442	8,650,541.00	659.34
Mississippi	5,435	1907	2,798,427.00	514.89
Total U.S.	1,568,200	2585	1,093,678,300.00	697.41

*Average of years 84-88.

SUNFLOWERS

No data available.

SUGAR BEETS

Sugarbeets are grown in 11 states with a total of 1,216,637 acres planted. Based on an average yield of 20.35 tons per acre and an average price to the farmer of $38,79 per ton, this crop is valued at more than $936 million. The sugarbeet root maggot affects approximately 55% of the planted acres and yield loss without chemical control is estimated at 4.93 tons per acre. There are no alternatives to chemical control. Resistance in sugarbeets to this insect does not exist and crop rotation for control is ineffective because of the root maggots ability to travel up to five miles to find a sugarbeet field.

Carbofuran is a highly effective pesticide for control of sugarbeet root maggot that is applied in a granular formulation at planting. It is applied directly into the seed furrow and covered with soil. Because of the lack of phytotoxicity when placed near the seed, the lowest registered rates are used in most growing areas. A side benefit of root maggot applications of carbofuran is that it also provides control of curly top disease by controlling the leafhopper vector. All alternative chemicals, except aldicarb, are phytotoxic to the plants when placed directly with the seed or near the seed at label rates necessary to control sugarbeet root maggot. The alternative chemicals require different application methods, higher rates and are placed in a wider band diluting their effectiveness.

Only carbofuran and aldicarb have nematicidal activity so carbofuran may become the material of choice in some cases (or labels developed for this reason) if aldicarb is lost.

Another major concern is that many of the alternatives to carbofuran are already under special review or will come under special review. This complicates the situation because it may not be so bad to lose one chemical but we do not know how many alternative materials will be kept or lost for control of sugarbeet root maggot.

About 650,000 acres of tobacco (all types) are grown in the United States. This includes about 366,000 acres of flue-cured tobacco, about 260,000 acres of burley tobacco, and about 24,000 acres of all other types of tobacco. These tobaccos have a combined average yield of about 2,078 lbs/acre, and an average sale price of about $1.59/pound. This results in a combined value of more than $2.15 billion annually.

IV. A. Current Registered Uses of Carbofuran on Tobacco.

1. Carbofuran 4F is labeled on flue-cured tobacco for control of flea beetles and wireworms, and for aid in the control of budworms and root-knot nematodes. On other types of tobacco, the 4F formulation is labeled only for control of flea beetles. Carbofuran 10G and 15G are labeled on flue-cured tobacco for control of flea beetles, wireworms, hornworms, and stunt nematodes, and for aid in the control of budworms and root-knot nematodes. On other types of tobacco they are labeled for control of flea beetles and hornworms, and for aid in the control of budworms.

2. Left unchecked, any or all of the pests for which carbofuran is labeled on tobacco may cause significant damage to the crop. Damage may be in the form of either reduced quality or reduced yields. Losses may be variable, ranging from reasonably minor losses to (in the case of uncontrolled hornworms) total loss. With the use of pesticides (including both carbofuran and alternative materials), insect and nematode losses can generally be held to about 1-3%.

3. Several options are available for the management of insect and nematode pests on tobacco. Crop rotation is an important option, but one that is not regularly practiced by growers. The use of economic thresholds and beneficial insects is also important. It has been shown (Johnson and Manley, 1982) that nearly one half of the budworms attacking tobacco are parasitized. Hornworms are frequently parasitized as well.

4. a. Overall use of carbofuran on flue-cured tobacco is very low, about 1% of the total acres. An exception to the normal use pattern is Virginia, where about 8% of the acreage is treated with carbofuran. Use seems to be about equally divided between granular and liquid formulations. However, for nematode control, the 4F formulation is predominant. Flue-cured is the only tobacco type for which carbofuran is labeled to control nematodes.

   Survey results show that carbofuran use in Kentucky and Tennessee, the major burley-producing states, is quite variable. About 20% of the Kentucky acreage is estimated to be treated with the insecticide, while in Tennessee, about 80% of the acreage is reported to be treated with carbofuran. The main target pest is the

tobacco flea beetle. The granular formulation is used predominantly, with only about 5% of the 2 carbofuran-treated acreage receiving the liquid form. It is anticipated that very few burley tobacco growers would switch to the 4F formulation of carbofuran if the granular formulation were not available.

b. Carbofuran use is relatively stable from year-to-year, and from area to area, except as noted in "a" above. The major variable use would be between tobacco types (flue-cured and burley).

c. Carbofuran is used on tobacco as a systemic, pre-plant, soil-incorporated insecticide/nematicide. There is but one application per season.

d. Carbofuran is applied to flue-cured tobacco at 4-6 lb AI/A. Most is probably applied at the 6 lb rate. The rate for burley tobacco is 3-4 lb AI/A, with the higher rate being most commonly used.

5. a. Carbofuran is applied to tobacco prior to transplanting.

b. Carbofuran is applied as a broadcast treatment and incorporated into the top 3 inches of soil.

c. Tobacco may be in close proximity to non-treatment crops, frequently separated by only a dirt road or ditch-bank.

d. Unfortunately, very little tobacco is rotated on a regular basis, though this is a recommended practice for insect, disease, and nematode control.

e. Due to the value of the crop, pesticides are frequently applied to tobacco without regard to treatment thresholds or field histories.

6. Although the potential exists for pest resistance to carbofuran, it is not likely to be strongly influenced by use patterns on tobacco, due to the limited acreage on which it is used.

B. Alternative Management Practices on <u>Tobacco</u>.

1. Several alternative pesticides, including both granular and liquid formulations, are available for each target pest for which carbofuran is labeled. These include aldicarb (in North Carolina), chlorpyrifos, disulfoton, ethoprop, fenamiphos, and fonofos in granular formulations. Formulations applied as liquid sprays include acephate, azinphosmethyl, carbaryl, chlorpyrifos, disulfoton, ethoprop, fenamiphos, fonofos, methomyl, oxamyl, and various <u>Bacillus thuringiensis</u> (<u>Bt</u>) compounds.

2. See A2.
3. See A3.

4. a. Nearly all tobacco is treated with an insecticide and/or nematicide at some time during the growing season. Acephate is a broad-spectrum insecticide that may be used on as much as 75-80% of the tobacco acreage. It is not effective against nematodes or wireworms, but is effective against all other target pests on tobacco for which carbofuran is labeled. Methomyl, chlorpyrifos, and the Bt compounds are the other most widely used materials. Chlorpyrifos, ethoprop, and fonofos are the only alternative products for wireworm control as a result of the recent loss of diazinon, though none are commonly used at this time. Other nematicides include disulfoton, ethoprop, fenamiphos, and oxamyl. Ethoprop and fenamiphos are probably the most commonly used materials at this time. Aldicarb is registered for use in North Carolina as an insecticide/nematicide. However it, too, is under review.

b. Overall use of the various materials does not vary greatly from year to year. Variability does occur, however, from year to year and from area to area as a result of particular pest problems.

c. The various granular materials (and some of the liquids) are applied as systemic, pre-plant, soil-incorporated insecticide/nematicides. Those materials are applied but once per season. The number of foliar sprays varies from area to area. They may be applied anywhere from about 1-6 times per season.

d. The insecticide/nematicide materials are generally applied at about the same rate as carbofuran, with only little variability from material to material. Application rate for the various foliar insecticides is quite variable, ranging from 0.45 lb AI/A for methomyl to 1.6 lb AI/A for carbaryl. The most commonly used material, acephate, is generally applied at 0.75 lb AI/A.

5. a. The various systemic insecticide/nematicides are applied to tobacco prior to transplanting. The foliar materials may be applied from shortly after transplanting until harvest. Acephate may be applied as either a foliar spray or as a transplant-water treatment.

b. Chlorpyrifos, disulfoton, ethoprop, fenamiphos, and oxamyl are applied as broadcast treatments and incorporated into the soil. Acephate may be applied as either a transplant-water treatment or foliar spray. Azinphosmethyl, carbaryl, chlorpyrifos, fonofos, methomyl, and the various Bt materials are applied as foliar sprays. The Bt materials may also be applied as baits.

c. See A5c.

d. See A5d.

e. See A5e.

6. The potential for resistance exists with any of the pesticides labeled for use on tobacco. Resistance has already been noted for some of these materials against the same or similar pests on other crops. Perhaps the greatest potential (and concern) for resistance on tobacco is with acephate, due to its overwhelming share of the insecticide market on tobacco. However, no resistance has been noted to date.

C. Economic nd Social Impacts on <u>Tobacco</u>.

1. Tobacco is the major cash crop in most of the states in which it is grown. It is primarily a southeastern crop. There are about 650,000 acres of tobacco (all types) grown in the United States. This includes about 366,000 acres of flue-cured tobacco (primarily in Virginia, North and South Carolina, and Georgia) and about 260,000 acres of burley tobacco (primarily in North Carolina, Virginia, Kentucky and Tennessee). For all types there is an average yield of 2,078 lbs/acre and an average sale price of $1.59/pound. This is a combined value of more than $215 billion annually.

2. Overall, there is very little carbofuran used on tobacco. It is used on only about 8% of the total acres. The most commonly used insecticide on tobacco is acephate, while ethoprop, and fenamiphos are the most commonly used nematicides.

3. The cost-effectiveness of carbofuran is close to that of alternative pesticides. Overall there would be very little difference and, in fact, carbofuran might be slightly more expensive than certain alternatives. However, for certain pest combinations, carbofuran would be the most practical pesticide choice. For certain pest combinations, the loss of carbofuran might require two or three different alternative pesticides to do the same job, and an extra trip across the field. This would, of course, be more costly.

4. At the present time, there are chemical alternatives to carbofuran which provide as good or better insect and nematode control. As long as these alternatives remain available, loss of carbofuran would result in no yield or quality reductions. There would be little or no harmful effects on insect or nematode control on tobacco. However, we are already seeing an erosion of available chemicals for insect and nematode control on tobacco, and there are few (if any) new pesticides coming along. As there becomes a greater and greater reliance on fewer available pesticides, there is likely to be a much more rapid development of resistance by insects to these pesticides.

5. The loss of carbofuran would have very little effect on tobacco production, except as noted above (4).

6. The loss of carbofuran would have very little effect on

consumers of tobacco products.

7. The loss of carbofuran would have very little economic effect on tobacco production or consumption.

8. The loss of carbofuran would have very few social/community impacts except in certain areas where pest complexes might make carbofuran the product of choice. Under those certain conditions, though limited, the loss of carbofuran might make tobacco production more costly, and affect entire communities.

V. Exposure Considerations.

A. Impact on Non-Target Organisms.

Carbofuran is a very toxic pesticide. It can cause phytotoxicity to tobacco even at labeled rates, under certain conditions. Carbofuran is also harmful to other non-target, or even beneficial, insects that may be on tobacco. It is non-selective. If applied properly, however, carbofuran should have very little effect on vertebrate organisms. This would be true of the granular formulations, and even more so of the liquid formulation.

B. Impact on Agricultural Workers and Applicators.

Although very toxic to vertebrates, including humans, there is reasonably little risk involved to agricultural workers and applicators if label instructions are followed. If label instructions are not followed, the most innocuous of materials can be deadly. We know of no fatalities to humans as a result of carbofuran use.

C. Impact on Water Quality.

The following information is clearly stated on carbofuran labels:

Carbofuran is a chemical which can travel (seep or leach) through soil and can contaminate ground water which may be used as drinking water. Carbofuran has been found in ground water as a result of agricultural use. Users are advised not to apply carbofuran where the water table (ground water) is close to the surface and where the soils are very permeable, i.e., well-drained soils such as loamy sands. Your local agricultural agencies can provide further information on the type of soil in your area and the location of ground water.

D. Residual Control Effects.

Carbofuran does have relatively long residual activity, although some alternative materials labeled for use on tobacco (e.g. chlorpyrifos) have as long or longer residual activity. The carbofuran label states that crops for which carbofuran is not labeled should not be

planted on soil treated with carbofuran for at least 10 months.

VI. Conclusions and Recommendations.

Although use of carbofuran on tobacco is relatively low, it remains important where it is used. There is no single chemical that exactly matches the range of control of carbofuran. For growers with a given pest complex, the loss of carbofuran might result in the need for using two or three alternative chemicals. Carbofuran can also be applied in conjunction with other farm operations. Use of some alternatives might result in extra trips across the field and, therefore, added costs.

Economic decisions by pesticide manufacturers, based primarily on the prospect of reregistration costs versus a relatively small market potential, is reducing the number of pesticides available for use on tobacco. Prospects for registration of new insecticide products are very limited. Additional regulatory action or decisions by companies to drop tobacco labeling on existing products may reduce the number of available products even more. Increased reliance on fewer insecticides may result in the development of insecticide resistance with a very limited selection of alternative products.

Although carbofuran is not widely used on tobacco, it does give growers another choice of materials to use. Under given pest conditions, it is the most practical and cost-efficient means of insect control. If we were to lose carbofuran from the marketplace, subsequent loss of other materials (either by removal from the marketplace or ineffectiveness through resistance) would make the production of tobacco either much more expensive or altogether impossible.

USE AND BENEFITS OF CARBOFURAN FOR INSECT CONTROL ON BURLEY TOBACCO

Approximately 260,000 acres of burley tobacco are grown in the United States, with an average yield of 2020 pounds per acre and an average sale price of $1.67 per pound. This results in an annual value of about $877 million.

Carbofuran 15G is labeled for use on burley tobacco as a systemic, soil-incorporated insecticide for use against flea beetles, budworms, and hornworms. The 4F formulation is registered in Kentucky through a 24-c state label. Only the 15G formulation is recommended by the Tennessee Cooperative Extension Service.

Survey results show that carbofuran use in Kentucky and Tennessee, the major burley-producing states, is quite variable. About 20% of the Kentucky acreage is estimated to be treated with the insecticide; while in Tennessee, about 80% of the acreage was reported to be treated with carbofuran. The main target pest is the tobacco flea beetle. Predominantly the granular formulation is used, with an estimate 5% of the carbofuran-treated acreage receiving the liquid form. It is anticipated that very few growers would switch to the 4F formulation of carbofuran if the granular formulation was not available.

Alternative insecticides provide equivalent control. As long as they remain available, the loss of carbofuran would not result in reduction in yield or quality and there would be little or no reduction of insect control on burley tobacco.

Economic decisions by insecticide manufacturers, based primarily on the prospect of reregistration costs versus a relatively small market potential, is reducing the number of insecticides available for use on burley tobacco for use on burley tobacco. Prospects for registration of new insecticide products are very limited. Additional regulatory action or decisions by companies to drop tobacco labeling on existing products may reduce the number of available products even more. Increased reliance on fewer insecticides may result in the development of insecticide resistance with a very limited selection of alternative products.

There is no other single chemical that exactly matches the range of control of carbofuran. For growers with a given pest complex, the loss of carbofuran might result in the need for using two or three alternative chemicals. Carbofuran can also be applied in conjunction with other farm operations. Use of some alternatives might result in extra trips across the field and, therefore, added costs.

COTTON

Entomologists in all cotton producing states were surveyed to determine the extent of carbofuran use on cotton. The only registered use of this product on cotton is for at-planting application of the 10% and 15% granular formulations and the 4 lb. active ingredient per gallon flowable liquid formulation to prevent damage by thrips and other early season pests. Initial results of the survey revealed that only one state included Furadan in their cotton insect control recommendations. In the other states, entomologists reported little or no use of carbofuran on cotton.

However, these entomologists reported that Furadan could be used effectively if alternative granular insecticides such as Temik, Thimet, Di-Syston, or Nemacur were not available. The level of efficacy obtained with Furadan against thrips was only equal to or somewhat less than that obtained with the other materials when the full labeled rate of Furadan was used. This treatment was considerably more expensive than the alternatives, so it was seldom used. When applied at less than labeled rates, Furadan produced erratic results.

In cotton producing areas where other crops were planted on farms growing cotton, surplus Furadan purchased for use on the other crops occasionally was used up on cotton This use precludes the need for storing excess product, which is judged to be a benefit from a safety as well as an efficacy point of view.

The state recommending the use of Furadan on cotton, Texas, reported that the amount used was negligible. On the Texas High Plains, approximately 1 million of the 3 to 4 million acres of cotton is treated with any insecticide at planting for thrips control. Temik is used on 80% of the treated acreage; Thimet (phorate) on 13% and Furadan on 7%.

Current labeling for Furadan on cotton calls for application of 1.0 lb. active ingredient per acre Texas research shows this rate to be effective most of the time, but it is more costly than alternative materials. The 0.5 lb active ingredient per acre rate is more economical, but results are erratic.

In summary, carbofuran receives very little use on cotton. Where it is used it is no better than other products currently available, and it is somewhat more expensive However, carbofuran will control early season cotton insect pests, and could be used if alternative chemicals were no longer available.

CRANBERRIES

Current Use Analysis Cranberries

EPA Registration of Carbofuran and Alternatives

INTRODUCTION:

Agricultural statistics indicate that cranberries were produced on approximately 29,000 acres in the United States during 1988. The principal regions of production are in the Northeast where Massachusetts, Wisconsin, and New Jersey account for 90% of the acreage. Oregon and Washington produce cranberries on approximately 2,855 acres, or about 10% of the U.S. acreage, in the southwestern coastal areas of the two states. Cranberries are harvested in the fall, primarily in October, by either flooding beds, beating the berries from vines and collecting the floating berries, or by using "dry harvest" machines which rake berries from the vines. The latter technique is employed by growers usually lacking adequate water or capabilities for holding flood water on the beds. It is estimated that the cost of establishing an acre of cranberries from timber or brush removal until the first producing year is approximately $20,000. This includes solid set sprinkler irrigation system, leveling, sand, vines, fertilizer, and pesticides. First harvest can occur in the fourth year but is usually 50% of potential production which may not occur until between the seventh and tenth year. Nationwide, average production approaches 100 cwt/A which is also typical of Washington and Oregon beds.

The black vine weevil (BVW), <u>Otiorhynchus</u> <u>ovatus</u> (Linn) has been recognized as a key arthropod pest of Pacific Northwest cranberries since the 1920's. Larvae of BVW damage cranberry vines by girdling roots. This injury is significant and results in the rapid decline of vines, greatly reduced yield, and ultimate death of infested vines as rapidly as in one field season. This species is parthenogenetic and each female is capable of producing from 200 to 600 eggs which are deposited on the soil of cranberry beds from late June through September. Larval damage begins in late July and is noticeable on top growth by the fall with dead and dying vines apparent the next spring. There is one generation a year with most adults dying during winter, although in warm years as much as 25% of the overwintering adults may survive to continue egg laying the next spring.

Cultural and chemical control (Azinphosmethyl and malathion) have not provided consistent nor effective control. The exception is carbofuran 15G, which is the only effective, legal, and economical alternative to manage BVW in cranberries. It is applied at the ai rate of 2 lb/A once in mid-June and again in July to control adult weevils prior to egg deposition. Granules are spread by rotary spreader to the vines and immediately washed through the vines and soil incorporated by overhead irrigation. Its use is limited only to cranberry beds that are "dry harvested" and sprinkler irrigated; however, it may not be used on beds that are flooded for irrigation or harvest. It was registered in 1983 for use in cranberries grown in Oregon and Washington only.

1). Carbofuran as Furadan 15G is labeled for use on nonflood harvested cranberry beds in Oregon and Washington. These are state labels (24c's) that allow two applications of Furadan 15G applied ca. June 20th and again one month later at the per treatment ai/acre rate of 2 lbs. to control <u>Otiorhynchus</u> <u>ovatus</u> (Linn), the BVW. These labels have been EPA approved and the product used on cranberry beds since 1983 and 1984 in Washington and Oregon respectively. It is the only effective insecticide registered for BVW control. Azinphosmethyl and malathion do not control larvae and their activity on BVW adults is poor.

2). Carbofuran is the only effective legal insecticide with federally approved state labels for use on cranberries to control black vine weevil. It was registered in 1983 and has been used on a total of 192A in Oregon and 1,036A in Washington during the crop seasons 1984 through 1988 inclusive:

Use of Furadan 15G in Pacific Northwest Cranberry Bogs

	OR	WA
1984	36	173
1985	36	201
1986	48	242
1987	48	272
1988	24	148

3). Performance Evaluation of Carbofuran and Alternatives:

BVW is the key arthropod pest of cranberries grown in Oregon and Washington. Feeding by the larvae cause root girdling and ultimate death of cranberry vines. In 1988 a sq ft of bearing cranberry bed had a market value of from $ .50 to nearly $1 per sq ft. It takes approximately 4 years for a bed to reach 50% of maximum production and from 7 to 10 years to realize 100% of prime production from planting time. BVW damage is ultimately expressed in the death of vines and is preceded by a season of greatly reduced production. Economic damage can be expressed as reduced yield over a period of 7 years. Ocean Spray Inc. estimates that it costs $8,000/A to re-establish cranberry beds taken out of production by BVW. Assuming average production levels of 100 cwt/A at ca. $50/cwt, it is estimated that the net return over a 7 year period from established vs replanted beds is $33,000/A vs $9,150/A - a loss of $23,850/A.

Currently, there are no effective, federally labeled, legal alternative insecticides to Furadan 15G for use in cranberries to control black vine weevil. Two possible non-chemical alternatives do exist. The first is a late fall flood of infested beds. Observations in Oregon and Massachusetts indicate that leaving flood water on beds after harvest for an extended period of time (2-3 wks) has occasionally effected larval mortality of economic significance. No scientific data exist to support this practice as being efficacious. Additionally, not all growers can apply floodwater or maintain floodwater on a cranberry bed to a necessary depth and/or duration to achieve control. Maintaining floodwater on a cranberry bed for an extended period can damage vines by creating anaerobic conditions or making vines susceptible to frost injury after floodwater

release. Finally, cranberry beds receiving Furadan 15G for weevil control must not be flood harvested. Dry harvested beds are usually harvested in this manner because of an inability to flood or hold floodwater on beds. Therefore, not all cranberry growers have the capability to use floodwater as a cultural alternative to carbofuran for root weevil control.

Three seasons of field trials indicate that certain species of insect parasitic nematodes offer potential for suppressing black vine weevil. At present and for the near future these represent a possible commercial option to carbofuran in cranberry beds for a small number of growers. Market supply is limited and the cost to treat an acre of BVW infested bed is $300. Additionally, many environmental parameters impinging on the effectiveness of these nematodes must be researched, such as the effect of low soil temperatures and effect of direct sunlight on nematode viability.

4). Applications of Furadan 15G as per label use in cranberries continue to provide effective and economical control of BVW for growers that have dry harvest capabilities. Field trials indicate from 70 to 90% control with proper timing and correct rates. Malathion and Guthion do not provide adequate control, nor do other federally labeled insecticides for use on cranberries but lacking black vine weevil on the label - Diazinon and Lorsban 4E.

Orthene, registered in 1987 by Chevron (now Valent) for control of blackheaded fireworm and other pests in cranberries, does provide limited fortuitous control of adult black vine weevils that may be present on the foliage at the time of application. However, this product can be used but once per crop season, 90 days prior to harvest, and the small percentage of a BVW population controlled with the timing of this one application does not appear to be economically significant.

Esfenvalerate was labeled for use in Washington in 1987 and 1988 via Sec. 18 for control of BVW. Treatment involved 85.35 and NA acres in 1987 and 1988 respectively. Excellent control was achieved on over 2/3 of the acreage treated as judged by grower and Ocean Spray observations. It is emphasized that esfenvalerate was labeled via emergency registration, **is not federally labeled** for use on cranberries, and may not provide environmental safety and/or benefits greater than carbofuran. It, too, can only be used on dry harvest beds. Additionally, if esfenvalerate does become federally labeled for use on cranberries, concepts of resistance management dictate that unilateral use of and reliance on this synthetic pyrethroid is not in the best interest of long term BVW management. Finally, repeated and continual use of the synthetic pyrethroid insecticides have been associated with the aggravation of secondary arthropod pests (mites) and honey bee repellency (cranberries are cross pollinated and BVW sprays w/esfenvalerate overlap the pollination period) can occur. It, too, may not be used on flood harvested cranberry beds.

5). Comparative Costs

In 1988 it cost ca. $45 an acre to treat cranberries twice as per label for BVW control. This is based on 4 lbs. ai used with a per lb. ai cost of $11.25. Growers use rotary spreaders to apply

the Furadan 10G. Most growers have this equipment as part of their farming equipment for granule herbicide/insecticide/fertilizer application for other purposes. Insect parasitic nematodes will cost $300 per acre. Supply may not be adequate to treat all infested acreage in the 1989 season.

6). The use of carbofuran granules in cranberry culture is restricted to the states of Oregon and Washington by FMC 24(c) labeling. The areas of use are Coos County, Oregon, and southwestern Washington. Furadan 15G is the only federally labeled insecticide to date that provides control of BVW in cranberry beds. There are no viable alternatives. Guthion and malathion are not effective for adult control in cranberries.

7). The cost of establishing an acre of cranberries is ca. $20,000/A from site preparation to first harvest (usually 4 years from planting and 50% of potential production that is realized in from 7 to 10 years). The cost of reestablishing an acre of producing cranberry bed in the Pacific Northwest is ca. $8,000. Assuming average production levels of 100 cwt/A at ca. $50/cwt it is estimated that the **net return** over a 7 year period is $33,000/A for established beds and only $9,150/A for replants - a difference of $23,850/A.

Because there are no effective federally registered alternative insecticides for BVW control in cranberries and because biological and/or cultural controls are not yet developed or feasible for many growers, a conservative estimate is that the loss of Furadan 15G to the cranberry industry would result in a continual loss of production area (perhaps 5% per year) until a suitable control alternative is available.

8). The following major limitations to the economic impact analysis for the loss of Furadan 15G to the cranberry industry were evident to this reviewer:

1. a lack of knowledge for the rate of spread of BVW or all current Pacific Northwest acres infested with BVW in need of control.

2. a lack of knowledge of the potential benefits and risks of using floodwater to control larval BVW infestations as well as the efficacy and feasibility of such a practice for those growers who have the ability to use and hold flood water.

3. lack of knowledge of the current and future availability of insect parasitic nematodes, their future efficacy, and the economics of their use in cranberry production.

4. lack of knowledge of the real value of esfenvalerate for BVW control, its projected registration date, negative and positive influences on other pests and possible detrimental effects on pollinators.

5. degree of fortuitous control of other pests such as cranberry girdler when Furadan 15G is applied to cranberry beds.

9). The loss of Furadan 15G for the control of BVW in Pacific Northwest cranberry beds would result in an estimated loss over a period of 7 years to the industry in these two states of

$7,632,000. This figure considers the 1987 acreage treated with Furadan (1988 figures were low because half of the infested WA acreage was treated with ASANA via a Section 18) x the difference in the 7 year net return average for BVW infested and replanted beds vs non-infested producing bogs ($23,850) ($23,850 x 320 = $7,632,000). It assumes that vines would be replanted. It does not consider further spread of BVW. If BVW spread is estimated at 5%/year and vine die out occurs, this would result in another 16 acres taken from production per year from the industry. Farm tried and proven alternatives for the control of this pest do not exist at this time nor appear to be available in the near future.

FOREST SEED

Due to Hurricane Hugo, information was not obtained.

GRAPES

There is only a limited registration for the use of carbofuran on grapes. California has registered carbofuran for control of nematodes (root-knot, dagger, and lesion) and the insect grape phylloxera for the 10G and 15G granular formulations and the 4F liquid formulation. Carbofuran 4F is also registered for use on grapes for control of the black vine weevil in the States of Washington and Oregon.

<u>California</u> <u>Use:</u>

Many pests have been identified on grapes, but a relatively small number (13 insects) were considered economically damaging and warranted control practices (Pearson, 1935). The grape phylloxera is an especially destructive plant louse native to the eastern United States where it originally infested the leaves and roots of the various species of wild grapes. The grape phylloxera was introduced into California sometime before 1874 and is now present in most grape - producing regions of the State (Slingerland and Crosby, 1914). However, little if any carbofuran is used in California for grape phylloxera control. Currently, it is speculated that less than 100 acres were treated with carbofuran for grape phylloxera control. Most control is accomplished by use of resistant root stock and certified phylloxera-free plantings.

The use of carbofuran for nematode control has diminished over the years in California. For sometime carbofuran was used alternately with Fenamiphos for nematode control with the idea of preventing resistance but this has diminished substantially.

That carbofuran which is applied to grapes in California is generally applied by trickle irrigation and should have no effect on birds because of lack of exposure.

<u>Oregon</u> <u>Use</u>:

Oregon reports no use of carbofuran on grapes for either nematodes or black vine weevil.

<u>Washington</u> <u>Use</u>:

Washington State finds that carbofuran liquid (4F) continues to be used for black vine weevil. The granular formulation is not widely used because it is less effective. Nematodes are not generally a problem on grapes in Washington and when problems occur, Fenamiphos is the material of choice. No carbofuran is used for nematode control in Washington State.

The black vine weevil (Brachyrhinus sulcatus) has caused extensive damage to grapes in south central Washington by feeding on berry pedicels and cluster stems. Cone (1963) estimates that losses due to feeding of black vine weevil can result in

reduction of yield in excess of three tons per acre. Although populations of black vine weevil are affected by crop cover and this can influence need for control, there is no straight line relationship between weevil density and ground cover sufficient to rely on for control purposes. The economic threshold for this pest has been established at 1 to 3 adults per plant per season (Cone, 1968). As larvae, the weevil feeds on the roots of the grape plants but seems inconsequential at this stage. However, the adults emerge in mid-May and lay eggs about 3 weeks after emergence. Therefore, control measures should be applied in this 3-week period.

The Washington State Extension Bulletin 0762 recommends 1 pound of active ingredient per acre applied as a liquid spray directed to the ground and lower vine in the earlier evening when the night feeding adults are emerging from duff and after birds have gone to roost. This is applied as a 3-foot band under the canopy and the middles are not sprayed. Approximately 6,000 acres are treated annually in this manner; each treatment lasting about 5 years.

Most grapes in the State of Washington (20,000 acres of concords and 10,000 acres of wine grapes) are juiced, and few grapes are used for fresh market. The yield under ordinary circumstances is about 9 tons/acre which in 1989 was valued at $210 per ton. Therefore, a reduction of 3 tons per acre reduces the yield by one-third.

Carbofuran is very important to this grape region since there is no alternative registered nor nearly as effective. Approximately 20-30 percent of the crop is treated annually, since one application will often reduce the population for 5 years or longer.

<u>Summary</u>:

The use of carbofuran on grapes is limited to the States of California and Washington. No granular use of carbofuran is thought to be applied in California, and most of the liquid formulation is applied underground by trickle irrigation where no bird exposure and no applicator exposure is likely to occur. Its usefulness as a grape nematicide where other alternatives are available is limited. Control of black vine weevil appears to be the most important use of carbofuran and then only in the liquid formulation. The expected loss of granular carbofuran on grapes will be extremely minor, but the registration for carbofuran 4F in Washington State is critical.

Furadan 15G (Carbofuran) is used sparingly in sorghum production in the U.S.; however, the use of this compound where needed is vital to the economic well being of growers. Geographically, the most important uses for Furadan centers in Kansas, Nebraska, Texas, Mississippi, Louisiana, Oklahoma and occasionally in Illinois and Iowa. Unavoidable losses due to chinch bug damage would occur to grain sorghum should Furadan 15G not be available in these states. All other reporting states use little to none Furadan 15G; therefore, the use of this compound appears to be restricted to chinch bug infested areas in the Midwest and is not widely used at all.

Central Texas and Kansas sorghum growers rely heavily on Furadan 15G and report that alternate compounds either are not effective for chinch bug control or they are too expensive. The table below lists alternate compounds and their relative efficiency for chinch bug control.

Chemical	**Cost/ac**	**Relative Efficiency**
TEMIK 15G	$16.75-$20.00	95%
COUNTER 15G	$11.75	90%
SEVIN 4F	$12.90	90%
FURADAN 4F	$13.10	85%
LORSBAN 15G	$ 7.00	80%
FURADAN 15G	$10.88	100%

There is no doubt that Furadan 15G is needed for grain sorghum production in certain states where the chinch bug is a limiting factor. After reviewing all data acquired during this survey, I suggest that Furadan 15 be retained for use on grain sorghum, especially in Kansas, Nebraska, Texas, Mississippi, Louisiana, Oklahoma, Illinois and Iowa.

Refer to State Summary for projected economic losses should Furadan 15G not be available for use on grain sorghum.

STATE SUMMARY

Estimated losses due to chinch bug, aphids and lesser cornstalk borer should Furadan 15g not be available for use on grain sorghum.

STATE	ECONOMIC LOSS*
ALABAMA	0
ARIZONA	0
COLORADO	0
FLORIDA	0
IDAHO	0
ILLINOIS	0
INDIANA	0
IOWA	0
KANSAS	$14,635,040
KENTUCKY	0
LOUISIANA	$ 127,680
MINNESOTA	0
MISSISSIPPI	$ 154,542
MISSOURI	UNKNOWN
NEBRASKA	$ 3,822,000
NORTH CAROLINA	0
NORTH DAKOTA	0
OHIO	0
OKLAHOMA	$ 27,631
SOUTH CAROLINA	0
TEXAS	$ 491,682
TENNESSEE	0
TOTAL	$19,258,575

*Calculated @ $3.04/Cwt value for grain for all states except Kansas -- Kansas value $3.58/Cwt.

Current Use Analysis - Sugarcane
EPA Registration of Furadan (Carbofuran)

Furadan (Carbofuran)[2.3-Dihydro-2,2-dimethyl-7-benzofuranyl methyl carbamate] is registered with EPA in the United States by FMC Corporation under the following formulation: Furadan 4F-EPA Registered Number 279-2876ZA, Furadan 5G-EPA Registered Number 279-2874AA; Furadan 10G - EPA Registered Number 279-2712AA; and Furadan 15G, EPA Registered Number 279-3023 and by Mobay Chemical Corporation, Agricultural Chemicals Division under the following formulations; Furadan 4F - EPA Registered Number 279-2876-3125-ZA and Furadan 15G - EPA Registered Number 279-3023-3125 for nematodes and wireworms.

State Recommendations:

There are four sugarcane producing states in the United States three of which recommend the use of Furadan on sugarcane. One hundred percent of the sugarcane acreage in Florida is treated for wireworm and nematode infestation of which 10% (38,200 acres) uses Furadan G. The remaining acreage (90%) is treated with Ethoprop 10G (Mocap) 40% Phorate 20G (Thimet) 35%, and Parathion 10G, 15%.

In Texas only 10% (3,450) of the total acreage is treated for wireworms, of this only 80% (2,760 acres) is treated with Furadan G. The remaining 20% is treated with Dasnit 15G (10%) and Dyfonate 10G (10%). In Louisiana, about 3% of the acreage is treated for wireworm control. Seventy-five percent (6,340 acres) is treated with Furadan 4F and 25% (2,078) is treated with Furadan G. No other insecticide is registered (labeled) for use on sugarcane in Louisiana for control of soil pests. Alternatives to Furadan used in other states (Phorate, Ethroprop, Dansanit, Parathion and Dyfonate) have shown good results.

Federal Guidelines:

Sugarcane borer and wireworms are the only insects mentioned on the label. However, Furadan will provide control of several species of grubs including the larva and adults of the sugarcane beetle (rough-headed corn stalk beetle).
Furadan is not labeled for use in Hawaii.

Use of Furadan and Alternatives; General History, Trends and Acreage:

Sugarcane is grown commercially in Florida, Louisiana, Texas and Hawaii with the following acreage: Florida - 382,000; Louisiana - 290,000; Texas - 34,500; and Hawaii 250,000. Cultural and planting practices vary considerably. However, planting dates for Florida, Louisiana and Texas are similar. Sugarcane is grown from one year old sugarcane stalks (plant cane). The seed pieces (stalk) are placed in a furrow in the soil and covered up with soil from August through October in Louisiana and Texas and through the following spring in Florida. The eyes at the joints (nodes) of the sugarcane sprout after several days in the soil and the sugarcane tillers emerge. The first years growth is

referred to as plant cane or cane grown from seed. Once the first year's growth in harvested, the second, third, and sometimes the fourth years growth is referred to as stubble cane. That is, three or four crops will be harvested from one sugarcane planting, before a new planting must be made. The number of stalks of sugarcane per acre begins to diminish after the first two years. This reduction in stalk number is attributed to several things including soil insects, nematodes, soil born diseases and climatic and cultural practices. Therefore, the soil insecticide is applied to the soil just prior to covering the seed cane in the furrow. Only one application of insecticide would be made every four to five years depending on the stubble crops. Louisiana would harvest two to three stubble crops from planted seed pieces or a total of three to four crops from one seed piece planting.

Florida is the leading sugarcane and sugar producing state with Hawaii second, Louisiana third and Texas fourth. Hawaii is the leading state in total tonnage in sugar per acre with Florida second and Louisiana last. Florida produces over 45% of the total sugar produced from sugarcane in the United States. Most of the sugarcane grown in Florida is grown in Palm Beach, Henley, Glades, and Martin counties all of which are located in the southern part of the state. In Louisiana and Texas sugarcane is also grown in the southern part of the state. Eight parishes (counties) account for about 85% of the Louisiana sugarcane and two counties in Texas grow most of the Texas sugarcane.

Although sugarcane production is subsidized the major limiting factor in maintaining sugar production in the United States is the lack of sugar mills. Sugarcane tends to be integrated with sugar processing, refining and distribution all in one company. Therefore, the sugar mill has to be within the immediate vicinity of where the sugarcane is grown in order to haul the raw cane to the mill to have it ground and produce into raw sugar. In Louisiana, sugarcane accounts for about 9% of the total farm value.

Although a high percentage of planted cane in the three mainland states is treated with a soil insecticide, only about 12 percent is treated with Furadan, and 7% of this use is in the state of Florida. Very few acres of sugarcane in Louisiana (8414A.-17%) and Texas (2760-6%) are treated with Furadan and none is used in Hawaii.

<u>Performance Evaluation of Furadan and Alternative Pest Infestation and Damage</u>:

All sugarcane soils in the state of Florida, Louisiana and Texas are infested with wireworms and/or grubs. Soil insecticides are used to control wireworms in sugarcane in Florida, Louisiana and Texas. The most common species of wireworms which attack sugarcane and *Conoderus falli*, and *C. lividus* which occur in cane in low numbers. *Melanotus communis M. depressus* and *M. lanei - opacicollis* cause a large percent of the damage. Melanotus in general are larger than the species of *Conoderus*. They also have a longer life cycle ranging from three to six years whereas, *Conoderus* life cycle is usually one year. Both genera can be readily controlled with the same type soil insecticides.

Comparative Efficacy - Comparative Yield and Quality:

If no soil insecticide is used, yields are reduced by about 10% from soil born insects. Tests comparing yield responses from the six registered insecticides have not been conducted with all six in the same test. However, separate tests over several years indicate that good results and similar yield responses have been obtained with all six insecticides. Quality of sugarcane is not effected by soil born insects. Since Furadan on sugarcane is applied in the soil, environmental problems are reduced to a minimum. However, groundwater (depending on soil type) may be of major consideration.

Comparative Costs:

If no soil insecticide is used on sugarcane the yield reduction is expected to be approximately 10% per year. There are alternatives presently available for use on sugarcane soil born insects. However, at least one of the alternatives is under review (Ethyl Parathion). Two other alternatives, Mocap and Phorate, are used extensively while the remaining two, Dansanit and Dyfonate are used very little. The average cost for Furadan in Louisiana is $15.00 and $38.50 and $40.50 in Florida and Texas respectively. The difference due to rate of use. Parathion and Phorate will average $28.50 while Dansanit costs $26.60, Dyfonate $32.00 and Mocap $45.00 per acre (Table 1).

The total chemical costs of pesticides of an established acre of sugarcane in Florida is about $61.00 per acre. The total establishment costs, which occurs every four years, is approximately $830.00. Therefore, chemicals represent about 7% of those total costs. However, this cost occurs every four years so these would be divided by four thereby reducing the annual cost considerably.

Use Impact Analysis:

Profile of Impact Areas - Specific States Influenced Parameters

The area that would impact the most by the loss of Furadan on sugarcane would be areas of Louisiana and Texas where Furadan is the primary or only soil insecticide. Florida would be effected considerably less and Hawaii would not be effected (since no Furadan is used at all in Hawaii). There will be a slight cost differential depending on the alternative taken should Furadan be lost, but there are alternative insecticides available for use.

Risk and Exposure:

Risk and exposure problems with soil insecticides are much less than for foliar insecticides. Exposure problems to the applicator can occur during application and handling of the insecticide. However, once the pesticide is applied and covered over with soil as is the case of sugarcane, then environmental and other hazardous problems are reduced to a bare minimum. If applied in soils that allow leaching downward to occur, ground water could be effected. Wildlife, honeybees, and other non-target organisms would have little exposure to the compound.

Integrated Pest Management is an important part of risk and exposure. In the case of soil borne insects the decision to use

or not use a pesticide must be based either on the history of soil borne insect populations in that particular field or a field adjacent to it. There is no method of applying a soil insecticide to sugarcane after the cane has been planted. There are other alternative soil insecticides for sugarcane, but there are no non-chemical methods of controlling soil borne insects in sugarcane. Insect resistance is a continuing problems with most insects. Of the six presently labeled insecticides for soil borne insects in sugarcane, five are considered organophosphates (Ethyl Parathion, Mocap, Dansanit, Dyfonate, Phorate and Chlorpyrifos) and one a carbamate (Carbofuran). A rotation using different soil insecticides on different years would contribute to a soil insect resistance prevention program. Furadan can be a very important part of this program.

<u>Economic</u> <u>Impact</u> <u>Analysis</u>:
Profile of Impact Areas and Specific States:

The geographic area of sugarcane production includes primarily four counties in Florida, eight in Louisiana, two in Texas and the island of Hawaii. All of the sugarcane of the mainland United States is grown along the southern coastline. The state of Hawaii uses no Furadan, and would not be effected by the loss of Furadan. Louisiana would be more seriously effected as only Furadan is registered in Louisiana for wireworm control in sugarcane.

<u>Use</u> <u>Impacts</u>:

As indicated on page 7, the cost of treating an acre of sugarcane is dependent on the formulations and on the rate used as compared to the alternatives which range in price form $27 to $45 per acre. However, only a small percentage (12%) of the sugarcane grown in the United States use Furadan as the primary soil insecticide of choice. The loss of Furadan would have its greatest effect on Louisiana (100% use) and a few growers elsewhere but would have less impact on the sugarcane industry as a whole.

<u>Market</u> <u>Impact</u>:

The loss of Furadan for use on sugarcane would have some market impact. Louisiana would be more effected as no other soil insecticide is used or recommended there and Texas would be effected as 80% of the treated sugarcane uses Furadan. Furadan loss would have less of an impact on Florida as only 10% of the acreage is treated with this insecticide. Hawaii would have no impact as Furadan is not used there.

<u>Summary,</u> <u>Conclusions</u> <u>and</u> <u>Recommendations</u> <u>-</u> <u>Sugarcane</u>:

1. It is the recommendation of this committee that although Furadan is not usually the primary soil insecticide used on sugarcane, that it should remain available to sugarcane growers as an alternative to other insecticides.

2. Furadan is not a threat to the environment as it is

presently used on sugarcane.

3. A minimum of non-target organisms are effected by the use of Furadan on sugarcane.

4. There are effective alternative pesticides for use on sugarcane.

5. Soil insecticides (including Furadan) are only used once every four (4) to five (5) years under "new planted seed cane".

6. Furadan is slightly more cost effective than alternative pesticides in Louisiana (rate recommended). In Texas and Florida it is slightly less cost effective due to rates used.

7. The granular formulation of Furadan is the most widely used and safest (no test) formulation on sugarcane.

8. Furadan can be an important part of an insect resistance management program.

9. Sugarcane yields are reduced about 10% if an effective soil insecticide is not used on "new planted cane" in wireworm infested soils.

10. Furadan is a highly toxic insecticide. However, the other primary soil insecticides used on sugarcane are also about the same mammalian toxicity level.

TABLE 1: Soil Insecticides labeled for use on sugarcane

Insecticide Common Name	Trade Name	Rate in a.i./A.	Primary Form.	Acres Treated	Cost ($) per Acre
Carbofuran	Furadan	1*	15G	2,078	13.00
Carbofuran	Furadan	3*	15G	40,960	39.00
Carbofuran	Furadan	1	4F	6,340	17.00
Ethroprop	Mocap	4	15G	152,900	45.00
Phorate	Thimet	3.9	20G	133,700	29.00
Parathion	Ethyl Parathion	5	10G	57,300	28.00
Dansanit		4	15G	345	27.00
Dyfonate		4	10G	345	32.00

Economic Impact of Carbofuran Deletion and Alternate Insecticide Deletions

Each state individually and all three combined show that without application of Furadan or the other soil insecticides there would be a substantial loss in revenues to each sugar growing state.

Louisiana shows a benefit of $266/A per year. Without Furadan an estimated loss of 84 thousand tons and $266/A. This loss projected for the state would amount $2.2 million per year.

Both Texas and Florida also project benefits from the use of Furadan and the alternate materials used in their states. With their loss would come a loss in production and therefore a loss in revenue.

The average of all states shows the same trend. The loss of the soil insecticide causes losses in production, reduced benefits from application and increased revenue losses due to changes in rates and costs of application.

These revenue figures should be multiplied by 3 or 4 to compensate for the fact that one treatment is made every three to four years based on the environmental growing conditions and application of the soil insecticides only at the time of planting and not annually. This would also effect the net benefit/acre and the per acre change from deletion.

It is very evident that the loss of any of these materials would remove a link in the pest management program of growing sugarcane. The loss of these soil insecticides will also gradually stress the production of sugarcane and could potentially reduce production in the United States and therefore force the price of sugar upward.

What is needed is good sound management program of these insecticides to prevent their loss and the loss of a unique commodity well adapted to its growing area.

SMALL GRAINS

Carbofuran granular formulations are not registered for wheat. Carbofuran 4F has Sec. 24(c) labels in Montana, North Dakota and Minnesota. The major target is grasshoppers on spring wheat although oats, barley and wheat are labeled. Grasshoppers are sporadic pests and until 1989 major uses of Furadan 4F were in Montana with treatments ranging from 5 to 50,000 acres in all states.

The 1989 treated acreage was:

900,000 wheat, North Dakota
250,000 wheat, Minnesota
100,000 wheat, South Dakota

Alternative pesticides include ethyl and methyl parathion, Penncap-M, and malathion and carbaryl on wheat. The products has allegedly caused bird mortality through avian consumption of sprayed grasshoppers.

Carbofuran registrations and SLN's for ornamentals and turfgrasses are limited.

Pine Trees for Christmas Tree Production

The greatest geographically diverse usage for carbofuran in the ornamental and turf category is for pine tree production for Christmas trees, approximately 7,000 total acres are involved in treatment. States utilizing the product include Alabama, Arkansas, California, Georgia, Illinois, Iowa, Louisiana, Mississippi, Oklahoma, Ohio, Rhode Island, South Carolina, Tennessee and Virginia. These usages were granted through SLN's (Special local needs) for control of the Nantucket Pine tip moth. North Carolina has a similar SLN for pines not destined for the Christmas tree market. Rates of active ingredient per tree varies with age of the tree as well as with the formulation utilized. Both flowable and granular formulations are prescribed. Frequency of application varies from once a year up to six times per year, again dependent upon method of application and formulation. In certain circumstances, pounds of active ingredient per acre of trees are extremely high in comparison to other usages on other crops. For example, California SLN 760208, November 3, 1988, prescribes a dosage of up to .285 oz ai/tree with a frequency of 6 drip irrigation applications/tree/year. This calculates out to over 186# ai/year. Three year old trees where 15g formulation are used are receiving between 11 and 12# ai/year. Total pounds of ai for all reported treatment areas is approximately 50,000.

Benefits derived from this usage were generally outstanding from the standpoint of control of the pest and is saving uncalculated man hours in expenses for pruning, damaged tips, and stunted trees. No evidence was found, or were there any reports, of avian kill or problems in worker applications. In assessing the quantities of ai utilized/annum with the drip method of application it certainly appears that dosages are extremely high and the possibilities of alternate methods of application of the product should be evaluated. In tree growing areas of high temperatures where daily water demands are high and this control procedure is followed, the possibility of leaching and shallow ground contamination should be considered.

Alternate methods of control of this pest on pine are available, but seemingly not as efficient nor as well researched at this time. Alternate chemicals available for tip moth include Chloropyrifos, Diflubenzuron, Dimethoate, Disulfoton, Acephate, and Fenvalerate.

The majority of the acreages for Christmas tree farms are small and range from a fraction up to 15 acres. Some tree farms are soley family operated and may require seasonal help for pruning and sales, and returns provide a minimal percentage of the family income. Other farms, however, are the sole source of income of the family and additionally provide steady employment for numerous individuals. The loss of carbofuran in both instances would currently cause additional expense to the operation and some financial hardship, depending on the severity

of the insect infestation.

No other insects or nematodes were targeted with the usage of this material.

The reviewers suggest continued usage of granules on the basis of need and lack of avian problems and a reevaluation of the drip method of application of the high dosages of the flowable formulation.

Bermuda Grass

Carbofuran has SLN usage for Bermuda grass seed production in Arizona and California. The purpose of the product is for thrip and leafhopper control. The flowable formulation is used for foliage application on an as needed basis applied by air or ground rig. One quart (1# ai)/acre/application is prescribe. Reports show up to 6#/ai/season is the maximum usage in the two reporting states.

Acreages of seed production vary annually as well as the severity of the targeted pest problems making an estimate of the impact difficult to ascertain. However, other materials are available which do a similar efficient job of control. No other commercial areas of sod production have sought similar registrations to the seed producers.

Other Greenhouse and Field Grown Ornamentals and Nursery Stock

Special local need registrations occur in Oregon and California for greenhouse field grown ornamentals and nursery stock for control of root weevils. Methods of application consist of container drenches in contaminated greenhouse materials and concentrated soil surface spray applications followed by sprinkling to move the product into the root zone. Direct application of the formulation into the sprinkling systems is prohibited.

This aspect of the review, including alternatives, is being reported on by another review group.

ECONOMIC ASSESSMENT

Economic Effect of Banning Granular Carbofuran

The estimates of economic effects and carbofuran use are based upon the expert assessment of the NAPIAP carbofuran team. The team estimated percent of acres treated with granular carbofuran, alternative control practices, percentage yield losses, and per-acre cost changes caused by using alternatives to carbofuran. The economic effects are short run, assuming that crop acreage is constant at the 1986-88 average of USDA published estimates. Yield losses were evaluated with 1986-88 average prices. (Acreage and prices for cucurbits and nonbearing peaches are not published by USDA. These estimates were obtained from State specialists and pertain only to those States where granular carbofuran is used.) The estimates in this section of the report may vary slightly from acreage, price, and impact estimates in previous sections, because acreage and price figures may pertain to a different time period.

Use of Granular Carbofuran

An estimated 5.5 million pounds of active ingredient (a.i.) of granular carbofuran is used per year in the U.S. (table 1). Corn accounts for 4.0 million pounds a.i. or about 72 percent of total use; about 6 percent of corn acreage is treated with granular carbofuran. Peanuts, rice, sorghum, sugar cane, and tobacco account for 1.1 million pounds a.i. or about 20 percent of use. Crops where 10 percent or more of the planted acreage is treated include rice, cucurbits, and bananas.

Aggregate Economic Impact

The estimated short-term, annual economic loss to consumers and producers of banning granular carbofuran would be approximately $51 million (table 3). The largest losses would occur to rice ($26.3 million) and sorghum ($18.1 million). The only measurable losses to consumers would occur with these two crops. Rice prices would increase by 8 percent, and consumers would lose $70.5 million. Sorghum prices would increase 3 percent, and consumers would lose $34.8 million. Losses of $2.3 million would occur in cucurbits and $1.1 million in sugar beets. Losses to the remaining crops would total $2.2 million per year; the loss to any one of the remaining crops would not exceed $1 million per year.

The overall effect on net revenues would be a gain of $55.8 million, because rice and sorghum producers gain $60.9 million from higher prices. However, higher commodity prices will reduce program payments to rice and sorghum producers. Accounting for changes in payments, rice producers would lose $23.2 million, and sorghum producers would lose $8.2 million. Producers of rice and sorghum who use carbofuran will bear these losses. Some producers who do not use granular carbofuran will gain from higher prices. Producers of other crops would lose $5.1 million so that the overall producer loss would be $36.5 million.

Discussions of specific crops follow. Carbofuran use is presented in table 1, yield and cost changes caused by a ban of granular carbofuran are presented in table 2, and the economic effects of such a ban are presented in table 3.

Effects on Field Crops

Alfalfa:

Granular carbofuran is used on about 6,250 acres in New Jersey and Vermont, less than 0.1 percent of U.S. alfalfa acreage. No alternatives are available, and there would be 25-50 percent losses due to loss of seeding stands and reduction in the productive life of fields. A carbofuran ban would cause a loss of about $490,000.

Corn:

Approximately 6 percent of U.S. corn acreage is treated with granular carbofuran, about 3.7 million acres, to control soil insects, European corn borers, and nematodes. Cost-effective alternatives are available for most situations. If granular carbofuran were banned, yields would decrease less than 1 percent on treated acreage, on average, while costs would decrease less than $1 per acre. However, a small number of producers could incur yield losses approaching 10 percent on treated acreage. Corn producers would lose about $1.4 million, which averages less than $0.50 per treated acre. (This estimate include nematode damages reported by Alabama and Kansas, while they were excluded from total loss estimates in the biological section on corn.) Price changes and consumer losses would be negligible, because U.S. corn production would decrease less than 0.1 percent.

Cotton:

Approximately 70,000 acres in the High Plains of Texas are treated with granular carbofuran to control thrips, less than 1 percent of U.S cotton acreage. There are a variety of cost-effective alternatives including, aldicarb, disulfoton, and phorate. The economic effect of a granular carbofuran ban would be negligible.

Peanuts:

Approximately 6 percent of U.S. peanut acreage, nearly 100,000 acres, is treated with granular carbofuran to control thrips, southern corn rootworms, and nematodes. Approximately 50 percent of the acreage is treated for nematodes and 50 percent for insects. However, both kinds of pests will be controlled on some acreage. The expert assessment shows an overall gain if peanut producers would change from carbofuran to alternatives; average yield would increase more than costs on acreage treated for nematode control. The yield gain would be less than 0.1 percent of total production. U.S. peanut production exceeds domestic consumption and USDA production quotas, so the yield change was evaluated at $0.14 per pound, the average 1985-87

contract price for non-quota peanuts for export (Schaub and Wendland, 1989). The estimated net gain is $117,000, an average gain of about $2.40 per acre for acreage treated for nematode control. However, Virginia peanut producers using carbofuran would lose about $607,300.

Potatoes:

No more than 2 percent of U.S. potato acreage is treated with carbofuran, and cost-effective alternatives exist. The economic effect of a carbofuran ban would be negligible.

Rice:

An estimated 18 percent of rice acreage, about 455,000 acres, is treated with granular carbofuran to control rice-water weevils. Yield would decrease by about 19 percent per treated acre, because there is no chemical alternative. As a result, U.S. rice production would decrease by 4 percent and prices could increase by 8 percent. The net economic loss would be $26.3 million. Consumers would lose $70.5 million. Net revenues would increase by $44.3 million, but income would decrease by $23.2 million because rice program payments would decline. This assumes 1986-88 average price, production, and program participation rate (94 percent) which results in payments declining $67.5 million. The users of granular carbofuran will bear the revenue losses. Among users of carbofuran, program participants would lose about $59 per treated acre, while nonparticipants would lose about $31 per treated acre. Nonusers of carbofuran who participate in the program would have no change in returns, while nonparticipants would gain about $28 per acre from higher prices.

Sorghum:

An estimated 3.5 percent of sorghum acreage, about 391,000 acres, is treated with carbofuran. However, users, primarily in Kansas, would average 37 percent yield losses from chinch bugs. Overall production would decline about 1.3 percent causing a 2.6 percent price increase. The net loss would be $18.1 million. Consumers would lose $34.8 million. Revenues would increase $16.7 million, but net income would fall $8.2 million. This assumes 1986-88 average prices, production, and program participation rate (71 percent) which results in payments declining $24.9 million. Users of carbofuran would bear the revenue losses. Users of granular carbofuran who participate in the program would lose about $47 per treated acre while nonparticipants would lose about $44 per treated acre. Nonusers who participate would have no change in returns, while nonparticipants would gain about $3 per acre.

Soybeans:

Only about 42,000 acres, less than 0.1 percent of U.S. soybean acreage, are treated with carbofuran. Cost-effective alternatives exist, so the economic effect of a granular

carbofuran ban would be negligible.

Sugar beets:

Approximately 60,000 acres of sugar beets, about 5 percent of U.S. sugar beet acreage, are treated with granular carbofuran to control sugar beet root maggot. Effective alternatives include aldicarb, phorate, terbufos, disulfoton, and chlorpyrifos. Yields would not decline, but costs would increase an average of about $18 per carbofuran-treated acre, and producers would lose approximately $1.1 million.

Sugar cane:

Approximately 6 percent of U.S. sugar cane acreage is treated with granular carbofuran at planting to control wireworms. Since sugar cane is a perennial crop, growing 3 to 4 years, approximately 2 percent of the sugar cane acres, about 60,000 acres, are treated each year. A variety of effective alternatives are available, but costs would increase about $12 per granular carbofuran-treated acre. Producers would lose about $190,000 per year or $570,000 over the life of the crop.

Tobacco:

Approximately 14 percent of tobacco acreage, about 85,000 acres, is treated with granular carbofuran to control flea beetles, budworms, hornworms, and nematodes. Cost-effective alternatives are available for most growers, so the economic effect of banning granular carbofuran would be negligible.

Effects on Specialty Crops

Bananas:

Approximately 10 percent of the bananas grown in Hawaii are treated with granular carbofuran to control rootborers. Most is used on the island of Oahu, but rootborer infestations are spreading. No alternatives to carbofuran are available, and uncontrolled rootborers can reduce yields 80 percent or more to put growers out of business. Currently, a ban of granular carbofuran could cause a loss to producers of about $190,000. Since domestically consumed bananas are largely imported, consumers would see little impact on prices. Conceivably, all acreage in Hawaii could be infested with rootborers which, if uncontrolled, could destroy the industry.

Cranberries:

Carbofuran use on cranberries is allowed only in Washington and Oregon. Approximately 1.1 percent of U.S. cranberry acreage is treated per year to control black vine weevil. Cost-effective chemical or cultural alternatives are not currently available for producers using granular carbofuran. Esfenvalerate was used effectively under emergency registration (Sec. 18) in 1988, but

does not currently have a federal label for cranberries. Banning carbofuran, assuming that esfenvalerate is not available, would force producers to reestablish cranberry beds. Losses would average about $3410 per acre per year for the 7 years needed to bring the new beds to full production. The economic loss of banning granular carbofuran would be about $1 million per year.

Cucurbits:

Granular carbofuran is used on approximately 38,000 acres of cucurbits to control nematodes, striped cucumber beetles, and spotted cucumber beetles. Effective alternatives to granular carbofuran are available, but yield losses would occur on cucumbers, melons, and squash. The alternatives include 1,3-D, carbaryl, esfenvalerate, ethoprop, methomyl, and oxamyl. However, the alternatives would raise costs ranging from an average of $15 dollars per carbofuran-treated acre for cucumbers to $67 per acre for squash. The overall yield effects would be small and have little effect on consumers. Producers would lose $2.3 million; melon producers would incur $1.1 million of that loss.

Grapes:

Very little granular carbofuran is used on grapes. The economic effect of a banning granular carbofuran would be negligible.

Peaches and Nectarines, Non-Bearing:

Granular carbofuran is used on 35,000 acres of non-bearing peach orchards in West Virginia and New Jersey for nematode control. The primary alternatives would be fenamiphos and the flowable formulation of carbofuran, which are more costly. About 5 percent of the acreage currently treated with granular carbofuran would be left untreated after a ban. The untreated trees would suffer lower yields and reduced bearing life. If granular carbofuran were banned, producers would lose about $136,000 or about $60 per treated acre.

Banning Carbofuran and Reducing Control Alternatives

For most crops, the economic effect of banning carbofuran would be small because effective alternatives are available. However, many of the pests controlled by carbofuran are potentially very damaging. The benefits of all alternatives used to control those pest is high while the benefit of any single alternative is low. Banning carbofuran would reduce the number of effective alternatives. This effect becomes important if some of the alternatives have health or environmental problems that could justify removal from the market. If enough alternatives are removed, the benefits of the remaining alternatives will become very high. So, if carbofuran were the only alternative remaining on the market, its benefits would be very high.

An important example is the control of soil insects on corn. EPA is considering at least two granular alternatives, phorate and terbufos, for special review. The cumulative effect of banning all three insecticides is unknown. While the effect of banning only carbofuran would be negligible, experts estimated that uncontrolled corn rootworms could reduce average corn yields by 12 percent on treated acreage in 6 States. Osteen and Kuchler (1986) estimated that the loss from banning all soil insecticides would be $2.2 billion. While corn producers could suppress rootworms by rotating, they would lose income by rotating to crops generating less income. Commodity program participants could reduce base acreage and program payments.

Sugar beets are another example. Aldicarb, terbufos, and phorate are three alternatives that EPA might remove from the market. Banning only carbofuran would have little impact on yield, although costs would increase $18 per treated acre. Without control, sugar beet root maggots would reduce yields on 55 percent of the acreage by 24 percent and also reduce quality.

Table 1 -- Granular carbofuran: crops treated and total use, 1986-88 averages

Crop	Acres Grown	Average Production	Units	Average Price	Acres Treated	Rate/ Treated Acres	Total Use
	(thousands)	(thousands)		Dollars	(%)	lb.a.i./acre	(1000 lb.a.i.)
Field Crops							
Alfalfa	26,341.00	81,876.00	Tons	71.68	0.02	1.50	9.48
Corn	62,177.00	6,747,709.33	Bushels	2.00	6.00	1.06	3,954.46
Cotton	10,131.50	13,312.17	Bales	273.60	0.70	1.00	70.92
Peanuts	1,567.07	3,776,995.00	Pounds	0.28 1/	6.30	3.30	325.79
Potatoes	1,247.27	365,648.67	CWT	4.96	1.8	3.00	67.35
Rice	2,528.33	140,835.33	CWT	6.14	18.40	0.50	232.61
Sorghum	11,171.67	751,641.33	Bushels	1.80	3.50	1.00	391.01
Soybeans	57,550.67	1,800,509.67	Bushels	6.07	0.07	1.50	60.43
Sugar beets	1,248.07	26,009.33	Tons	24.70	4.80	1.00	59.91
Sugar cane	775.57	29,958.67	Tons	18.87	6.15 2/	3.79	180.82
Tobacco	600.12	1,234,246.00	Pounds	1.58	14.12	1.18	100.24
Specialty Crops							
Bananas	1.10	9,753.30	Pounds	0.30	10.00	2.00	2.20
Cranberries	25.43	3,660.00	Barrels	29.73	1.10	4.00	1.12
Cucurbits							
Cucumbers	38.95 3/	227.34 3/	Tons	250.04	24.66	1.81	17.39
Melons	82.35 3/	680.50 3/	Tons	158.62	23.99	2.03	40.1[illegible]
Squash	24.34 3/	114.33 3/	Tons	451.74	7.99	1.81	3.5[illegible]
Pumpkins	13.16 3/	187.65 3/	Tons	122.14	51.61	1.21	8.2[illegible]
Grapes	762.57	5,411.37	Tons	241.00	0.00	10.00	0.0[illegible]
Peaches,non-bearing	6.64 3/	NA		NA	34.63	0.25	0.5[illegible]
Ornamentals	—	—	—	—	—	—	—

NA = Not appropriate.

__ = No information.

1/ Reflects prices of quota and non quota peanuts.

2/ Over the life of the sugar cane crop; annual use would be 1/4 to 1/3 this amount.

3/ Acreage and production in states with granular carbofuran registration.

Table 2 -- Banning granular carbofuran: yield, production, and cost changes

Crop	Yield Loss/ Treated acres	Production Loss	Units	Cost Change / Treated Acre	Total Cost Change
	(%)	(thousands)		Dollars	(Thousands Dollars)
Field Crops					
Alfalfa	40.00	7.86	Tons	(12.00)	(75.86)
Corn	0.52	2,105.29	Bushels	(0.75)	(2,797.97)
Cotton	0.00	0.00	Bales		0.00
Peanuts	(1.37) 1/	(3,259.92) 2/	Pounds	3.85	380.09
Potatoes	0.00	0.00	CWT	1.00	22.45
Rice	19.40	5,027.26	CWT	(12.62)	(5,870.99)
Sorghum	37.00	9,733.76	Bushels	1.00	391.01
Soybeans	0.00	0.00	Bushels	0.00	0.00
Sugar beets	0.00	0.00	Tons	18.40	1,102.29
Sugar cane	0.00	0.00	Tons	11.87	566.17 3/
Tobacco	0.00	0.00	Pounds	0.00	0.00
Specialty Crops					
Bananas	67.00	653.47	Pounds	(55.60)	(6.12)
Cranberries	0.00	0.00	Barrels	3,410.00 4/	954.00 4/
Cucurbits					
Cucumbers	1.91	1.07	Tons	15.39	147.82
Melons	0.25	0.43	Tons	54.78	1,082.22
Squash	(0.14) 1/	(130.00) 2/	Tons	66.95	130.20
Pumpkins	4.01	0.37	Tons	51.03	346.59
Grapes	0.00	0.00	Tons	0.00	0.00
Peaches, non-bearing	NA	NA		59.50 4/	136.82 4/
Ornamentals	—	—	—	—	—

NA = Not appropriate.

__ = No information.

1/ Yield increase.

2/ Production increase.

3/ Over the life of the sugar cane crop; annual impact would be 1/4 to 1/3 of this amount.

4/ Average annual impact, includes value of future production losses.

Table 3 -- Banning granular carbofuran: economic effects

Crop	Price change	Net Revenue change	Consumer Loss	Net Effect
	Percent	--------------------Thousand Dollars	--------------	
Field Crops				
Alfalfa	0.00	(487.55)	0.00	(487.55)
Corn	0.00	(1,405.59)	0.00	(1,405.59)
Cotton	0.00	0.00	0.00	0.00
Peanuts	0.00	117.43 1/	0.00	117.43
Potatoes	0.00	(22.45)	0.00	(22.45)
Rice	8.30	44,225.77 2/	70,503.36	(26,277.58)
Sorghum	2.59	16,675.96 3/	34,814.63	(18,138.66)
Soybeans	0.00	0.00	0.00	0.00
Sugar beets	0.00	(1,102.29)	0.00	(1,102.29)
Sugar cane	0.00	(566.17) 4/	0.00	(566.17) 4/
Tobacco	0.00	0.00	0.00	0.00
Specialty Crops				
Bananas	0.00	(189.93)	0.00	(189.93)
Cranberries	0.00	(954.00) 5/	0.00	(954.00) 5/
Cucurbits				
Cucumbers	0.00	(231.95)	0.00	(231.95)
Melons	0.00	(1,559.94)	0.00	(1,559.94)
Squash	0.00	(487.04)	0.00	(487.04)
Pumpkins	0.00	(53.67)	0.00	(53.67)
Grapes	0.00	0.00	0.00	0.00
Peaches, non-bearing	0.00	(136.82) 5/	0.00	(136.82) 5/
Ornamentals	—	—	—	—
Totals		53,821.76	105,317.98	(51,496.22)

__ = No information.

1/ $607.3 thousand loss in VA.

2/ Rice producers lose $23.2 million when accounting for charges in deficiency payments.

3/ Sorghum producers lose $8.2 million when accounting for changes in deficiency payments.

4/ Over the life of the sugarcane crop; annual impact could be 1/4 to 1/3 of this amount.

5/ Average annual impact, includes value of future production losses.

WILDLIFE

V. Exposure Considerations (Biological Effects)

A. Impact On Non-target Organisms

1. Survey of State Agency Personnel Regarding Wildlife Mortality.

Methodology:

Dr. Gary San Julian of North Carolina State University surveyed an extensive list of state and federal agencies likely to have documentation or knowledge of wildlife mortality related to pesticides. The survey asked whether the respondent had documentation of wildlife mortality due to carbofuran, and it also requested specific details about such documented incidents (crop or site, formulation, rate and time of application, whether the application complied with label directions, etc.)

The survey was mailed February 17, 1989 with a response requested no later than April 1, 1989. No follow-up was conducted for non-respondents.

Results:

Completed surveys were returned from every state, and multiple copies were returned from many states where copies had been sent to multiple agencies or persons. A summary of the survey returns is as follows:

Total Surveys Sent: **336**
Total Surveys Returned: **196 (58.3%)**

Returned with no data (not appropriate respondent): **6**

Respondents having no documentation of wildlife mortality due to Carbofuran: **169 (90%)**

Respondents having documentation of wildlife mortality due to Carbofuran: **18 (10%)**

Of the above respondents, total number of such incidents represented: **30 (excluding CA)**

Of these incidents, the number in which a granular formulation was known or suspected to have been used: **7**

Of these granular uses, number in which the product was thought to have been applied according to label instructions: **4**

Table 1 lists information from the above four applications where wildlife mortality was observed.

State	Crop/Site	Formulation	Lbs/ac	Wildlife Killed	Residue Analysis
KS	corn	15G	8.7	blackbirds, doves, barn swallows	no
KY	peppers	granular	ca 10	2 robins, 1 crow	no
NJ	peppers	15G	3.3	7 house finches	yes
TX	sorghum	15G	6.9	7 starlings	no

Kansas = Wilk, S.
Kentucky = May, J.
New Jersey = Kosinski, R.
Texas = Parker, R.

The summary data indicate that in only 4 of 30 incidents where wildlife loss occurred was granular carbofuran believed to have been applied according to label directions. In the other instances, applicators either misapplied the pesticide in some manner, or the product was deliberately misused for the purpose of poisoning depredating wildlife. Inasmuch as number of survey returns was deemed very good and geographic coverage of responses was also excellent, we believe this survey to be as complete a picture as can be obtained from such state and federal agency personnel nationwide who are likely to have knowledge and/or records of carbofuran hazards to wildlife. Thus, for all reported incidents involving wildlife believed poisoned by carbofuran, 26 of the 30 incidents (86.7%) occurred when label directions were not followed. On the basis of this survey, we conclude that carbofuran use, when application conforms to current labels, appears to result in negligible hazard to wildlife. Further, when such hazards have occurred, it appears to have been when incorporation of the material was absent or incomplete.

2. Survey of Commodity Specialists On Environmental Concerns Regarding Use of Carbofuran

Methodology:
Members of the Benefits Assessment team working in specific commodity/ crop areas cooperated in polling their contacts concerning environmental concerns related to use of carbofuran. The standard question asked of respondents to the various surveys conducted by crop specialists was the following:

"Are there any environmental reasons that would deter you from using carbofuran for your particular crops/sites? If yes, please list the most important reasons."

Results:
Responses received were as follows:

Commodity/Crop

Alfalfa

Of 9 states responding, one (WY) indicated concern regarding potential groundwater contamination. Four states (AZ, CA, CO, ID) indicated concern about mortality to pollinators, particularly honeybees. California indicated past incidences of bird kills (primarily waterfowl) involving applications of the 4F formulation for control of alfalfa weevils. The respondent dtated "County Agricultural Commissioner personnel together with applicators and Pest Control Advisors can and have eliminated this problem by monitoring waterfowl activity in and around alfalfa fields prior to recommending an insecticide for weevil and/or aphid control.

Bananas

No respondents mentioned concern about bird kills.

Corn

Of a total of 36 respondents, 20 replied an unqualified "no" to the question, while five additional respondents gave a qualified "no." Qualifications given were: carbofuran causes no greater environmental concerns than other corn soil insecticides; and, concerns are absent if the material is applied at proper label rates following use guidelines and directions. Seven respondents expressed concern about groundwater contamination, suggesting that carbofuran should not be applied where water tables are close to the surface, where soils are very permeable, or on slopes adjacent to bodies of water. Several respondents mentioned concerns about carbofuran's solubility and soil permeability.

Cotton

Respondents indicated very little current use of carbofuran in cotton, and respondents were unaware of any environmental concerns in regard to its use in cotton.

Cranberries

Respondents indicated no knowledge of hazards to birds or other wildlife as a result of carbofuran use in cranberry production.

Cucurbits

Nine of 11 states' responses contained wording suggesting that proper incorporation of granular carbofuran would alleviate environmental concerns (presumably involving non-target hazards). One state (FL) expressed concern about potential groundwater contamination.

Forest-Seed

No significant environmental hazards have been found to occur as a result of current use of carbofuran in forest seed plantations. Used primarily in Southern pine seed orchards, such applications have received considerable study by USDA Forest Service, which has developed improved application machinery and techniques which significantly reduce the amount of granular material available to birds. In a joint study with the U.S. Fish and Wildlife Service, it has been shown that such applications have no significant effect on bird populations. Further, surveys in pine seed

orchards following application have failed to show dead birds. Additional studies have resulted in development of designs for catch ponds to mitigate any potential pesticide runoff that may occur; under normal conditions, it has been determined that no pesticide runoff occurs. A predictive model for carbofuran residues in runoff has been developed.

Grapes

The only significant use of granular carbofuran formulations in grapes occurs in California. Respondents reported no specific concerns about environmental hazards when the product is used according to label directions.

Ornamentals

Of 35 respondents, none mentioned any environmental concerns.

Peaches (non-bearing)

Of the six most important states, only 2 indicated some environmental concern, and neither made mention of hazards to birds.

Peanuts

Five of 10 important peanut-producing states indicated concerns about environmental hazards. Of these states, only one (OK) indicated a concern which implied knowledge of hazards to birds, express by the statement "all granulars kill birds."

Pineapple

Question was not asked of commodity specialists.

Potatoes

No respondents reported any environmental concerns.

Rice

No respondents from any state except California expressed concerns about environmental hazards resulting from carbofuran use in rice. About half of the respondents from California indicated concern about hazard to waterfowl, in particular, when carbofuran applications are made in rice and when label restrictions are not closely followed.

Small Grains

In response to the question, there were no environmental concerns mentioned. However, in subsequent contact with commodity specialists, two persons had knowledge of undocumented cases in which birds were affected, presumably secondarily by eating grasshoppers contaminated with carbofuran.

Sorghum

The question was not asked of commodity specialists. However, the following statement was made by H. Leroy Brooks, Extension Specialist- Insecticides (Pesticide Safety) at Kansas State University: "Furadan accounted for almost half of the granular sales in Kansas in 1988. This may well represent one of the heavier areas of Furadan use in the country (especially on sorghum). In spite of this, we have not been aware of a problem bird mortality

associated with the granular use of this product."

Soybeans
The question was not asked of commodity specialists.

Strawberries
Respondents reported concerns related to a) groundwater contamination, and b) potential hazard to birds if Furadan 4F were applied directly to fruit of strawberries. Most labels state that such applications should not be made when berries are present.

Sugar Beets
Of 15 respondents, only one (from California) reported knowledge of an environmental concern, specifically, death or injury caused to horned larks feeding on newly-germinated sugar beet plants. The respondent reported hearing of one or two such incidents per year. Inasmuch as horned larks can cause significant damage to the crop when feeding on young plants and in legal terms can be controlled when such damage occurs, such an occurrence is not necessarily deemed a problem. In fact, the respondent indicated some knowledge of carbofuran in sub-lethal amounts causing a learned aversion in the birds, which results in their not feeding on young sugar beets in the future.

Sugar Cane
None of the respondents reported environmental problems or concerns (most use flowable formulations).

Sunflowers
The question was not asked of commodity specialists.

Tobacco
Of 8 respondents, only one mentioned a concern about birds by stating "carbofuran is toxic to birds and humans."

3. Carbofuran Use in California

Inasmuch as many of the incidents involving carbofuran hazards to wildlife cited by EPA have involved uses in California, particular attention has been given to agricultural uses of this pesticide in this state. Hazards have been noted in association with carbofuran use in rice, alfalfa, and grapes.

Rice
Use of carbofuran granular formulations in California rice has in the past resulted in deaths of birds, which was of concern to wildlife and agricultural personnel in California (Littrell 1988). These deaths occurred both in instances of normal agricultural use as well as possible misuse (e.g. use of carbofuran to control crayfish). Steps have been taken in recent years to resolve these problems.

Extensive aerial and ground surveys conducted over rice fields in the spring of 1987 and 1988 by the California Dept. of Fish and Game revealed only three ducks dead in the spring of 1987 and none in 1988 (Bontadelli 1989a). No reports of dead waterfowl related to carbofuran use in spring 1989 were received

(Littrell, personal communication, 9/25/89). New use restrictions attached to permits for carbofuran use in California counties where rice is an important crop are believed to have significantly reduced hazards to wildlife. Such conditions typically relate to incorporation requirements for the granular formulation, clean-up requirements at sites where aircraft are loaded, and choice of loading sites. The California Dept. of Fish and Game believes that the hazard to ducks in the spring "has been satisfactorily reduced with losses approaching zero," and therefore "...cannot concur with the EPA assessment that the application of granular carbofuran to rice represents an unreasonable risk to birds in California" (Bontadelli 1989a). Educational programs and better enforcement of pesticide use and misuse has contributed to a major reduction in incidents of fall waterfowl kills, as well. Further, state agencies in California believe that current use restrictions and monitoring have solved this problem of hazards to ducks and other avian wildlife. In a letter replying to EPA queries about aerial surveys of rice fields conducted by California Fish & Game, Director Bontadelli states "all California interests have worked together to eliminate the threat of carbofuran to wildlife" (Bontadelli 1989b).

Regarding cancellation of carbofuran, the California Dept. of Food and Agriculture has stated that such action would compel rice growers to increase clean cultivation practices on field margins as a cultural method to reduce rice water weevil populations, for which there are no highly efficacious substitute pesticides. This action may result in a 30% reduction in nesting waterfowl populations in the Sacramento Valley, the primary rice-growing region of the state (Magee 1989). Thus CDFA states "we find the proposed cancellation of all carbofuran granular registrations to be a greater threat to wildlife than all the losses attributed to its use to date... The availability of carbofuran granules has greatly benefited waterfowl in California" (Magee 1989).

Alfalfa

No granular formulations of carbofuran are presently labeled for use on alfalfa in California. Application of the 4F formulation can potentially be hazardous to waterfowl (ducks, geese, coots) which graze on alfalfa. Label instructions state the importance of surveying fields for the presence of feeding waterfowl prior to making pesticide application. According to California Fish & Game officials, there has been only one reported loss of birds feeding on treated alfalfa in the past ten years. This incident, which occurred in the Imperial Valley in spring 1986, involved the death of 25 geese which moved onto the treated field following application (Littrell, personal communication, 9/25/89).

Grapes

Applications of granular formulations have been implicated in bird kills in grape vineyards in California. A report from Lake County indicates that a number of songbirds were killed during fall applications in 1986, 1987, and 1988. Additional information indicates that at least part of this hazard resulted from improper disposal of pesticide containers, which provided a concentrated source of the pesticide for birds to ingest. The report also indicates that the material was not immediately

incorporated, and thus the application did not comply with label recommendations. Timely incorporation of the granular material would have reduced this hazard.

In the opinion of California Dept. of Fish and Game officials, proper application of carbofuran and adherence to label instructions will alleviate any significant hazard to birds that such uses may otherwise create (Littrell, personal communication, 9/25/89).

VI. Conclusions and Recommendations

Survey data obtained by the Benefits Assessment Team from crop and commodity specialists throughout the U.S. indicate that there is not great environmental concern among this group about continued use of granular carbofuran formulations. A thorough survey of state and federal agencies for documented records of wildlife kills caused by carbofuran revealed that in most instances where hazards had occurred, the product was misused and the label directions were violated, either accidentally or purposefully. Little or no evidence was obtained to document that granular carbofuran, when applied and incorporated according to label directions, causes anything other than incidental mortality of wildlife. Such data indicate to us that carbofuran use, as currently practiced in American agriculture, poses no little hazard to populations of birds or other wildlife.

It is further noted that in those occasions in the past where use practices may have caused concerns about potential wildlife hazards (e.g. use of carbofuran in rice fields in California), new use restrictions along with educational programs aimed at applicators have successfully alleviated such hazards. In the major rice production areas of California, it is further held by the state agency responsible for wildlife management that the former problem of use of carbofuran in areas used by waterfowl has been solved. Both the California Dept. of Fish and Game, and the Department of Food and Agriculture believe that loss of carbofuran for rice growers will result in a significant detriment to rice growers and consequently to waterfowl habitat and waterfowl populations in California. They believe its continued use provides benefits to waterfowl and other wildlife that far outweigh any disadvantages its continued use might incur.

CONCLUSIONS AND RECOMMENDATIONS

The recommendations contained herein are based on the assumption that the alternatives (pesticides) listed for specific site/pest/crop use remain viable. Loss of registration or availability of these alternatives to carbofuran would require re-examination of recommendations listed below.

Based upon the results of the benefits analysis the continued registration of carbofuran on the following sites is considered essential:

a. Bananas- in Hawaii, carbofuran is the only registered pesticide known to provide effective control of the banana root borer. It is estimated that there would be an 85% yield loss in production of bananas if carbofuran is lost.

b. Rice- carbofuran is the only labeled insecticide for the control of the RWW (rice water weevil), the US's most damaging insect pest of rice. Depending on the price of rice received by producers, the annual benefit of carbofuran to U.S. rice farmers is estimated between \$24.5 million and \$48.7 million.

c. Cranberries- especially in the Pacific Northwest- this is the only material that works for control of the black vine weevil. If carbofuran was lost, an estimated loss of 5% of the current NW cranberry acreage could be lost per year.

d. Grain Sorghum- Furadan 15G is needed for chinch bug control in the states of Kansas, Nebraska, Texas, Mississippi, Louisiana, and Oklahoma. Alternative pesticides are either more costly or much less effective.

Continued analysis of carbofuran on other registered crops yielded the following results.

a. Corn- only a small percentage of the corn acreage, mostly in the south, is treated with carbofuran. The major problem with loss of carbofuran to corn growers would be the problem of pest resistance management. Carbofuran is the only carbamate soil insecticide used and its elimination would exclude a whole chemical class from the rotation scheme as a management tool. Price changes and consumer losses would be negligible.

b. Curcubits- Most states feel that there are alternative pesticides for carbofuran. However, there are concerns regarding pollinator toxicity with those alternatives. A yield decrease is estimated if carbofuran should be lost resulting in a monetary loss of \$2.3 million.

c. Sugar beets- There are alternatives to carbofuran on sugar beets, however, many of them are under special review. If carbofuran is lost, producers would lose about \$1.1 million.

Very little or no carbofuran is used on or negligible impact from loss of carbofuran would occur on the following crops:

Tobacco- 14 percent of tobacco acreage is treated but there are alternatives.

Alfalfa- less than 0.1 percent of total U.S. alfalfa acreage is treated.

Pineapples- no carbofuran used.

Cotton- less than 1 percent of total U.S. cotton acreage is treated.

Sugar cane- 6 percent of crop treated; economic loss of about $190,000 per year without carbofuran.

Potatoes- less than 2 percent of total U.S. potato acreage is treated.

Peanuts- the only negative impact would be on Virginia peanut growers, where there would be a monetary loss of $0.6 million.

Soybeans- alternatives available less than 0.1 percent total soybean acreage is treated.

Strawberries- carbofuran granular formulations are not used.

Grapes- very little used.

Peaches & Nectarines, nonbearing- producers would lose about $136,000.

Ornamentals- important in localized areas. More information will be collected by a special ornamentals group.

No information was collected on carbofuran use on peppers, sunflowers, forest-seed and small grains.

WILDLIFE

The summary data indicate that in only 4 of 30 incidents where wildlife loss occurred was granular carbofuran believed to have been applied according to label directions. In the other instances, applicators either misapplied the pesticide in some manner, or the product was deliberately misused for the purpose of poisoning depredating wildlife. Inasmuch, as number of survey returns was deemed very good and geographic coverage of responses was also excellent, we believe this survey to be as complete a picture as can be obtained from such state and federal agency personnel nationwide who are likely to have knowledge and/or records of carbofuran hazards to wildlife. Thus, for all reported incidents involving wildlife believed poisoned by carbofuran, 26 of the 30 incidents (86.7%) occurred when label directions were not followed. On the basis of this survey, we conclude that carbofuran use, when application conforms to current labels, appears to result in negligible hazard to wildlife. Further, when such hazards have occurred, it appears

to have been when incorporation of the material was absent or incomplete.

"Survey data obtained by the Benefits Assessment Team from crop and commodity specialists throughout the U.S. indicate that there is not great environmental concern among this group about continued use of granular carbofuran formulations. A thorough survey of state and federal agencies for documented records of wildlife kills caused by carbofuran revealed that in most instances where hazards had occurred, the product was misused and the label directions were violated, either accidentally or purposefully. Little or no evidence was obtained to document that granular carbofuran, when applied and incorporated according to label directions, causes anything other than incidental mortality of wildlife. Such data indicate to use that carbofuran use, as currently practiced in American agriculture, poses little hazard to populations of birds or other wildlife."

For most crops, the economic effect of banning carbofuran would be small because effective alternatives are available. However, many of the pests controlled by carbofuran are potentially very damaging. The benefits of all alternatives used to control those pest is high while the benefit of any single alternative is low. Banning carbofuran would reduce the number of effective alternatives. This effect becomes important if some of the alternatives have health or environmental problems that could justify removal from the market. If enough alternatives are removed, the benefits of the remaining alternatives will become very high. So, if carbofuran were the only alternative remaining on the market, its benefits would be very high.

An important example is the control of soil insects on corn. EPA is considering at least two granular alternatives, phorate and terbufos, for special review. The cumulative effect of banning all three insecticides is unknown. While the effect of banning only carbofuran would be negligible, experts estimated that uncontrolled corn rootworms could reduce average corn yields by 12 percent on treated acreage in 6 States. Osteen and Kuchler (1986) estimated that the loss from banning all soil insecticides would be $2.2 billion. While corn producers could suppress rootworms by rotating, they would lose income by rotating to crops generating less income. Commodity program participants could reduce base acreage and program payments.

Sugar beets are another example. Aldicarb, terbufos, and phorate are three alternatives that EPA might remove from the market. Banning only carbofuran would have little impact on yield, although costs would increase $18 per treated acre. Without control, sugar beet root maggots would reduce yields on 55 percent of the acreage by 24 percent and also reduce quality.

The few problems associated with carbofuran use and bird kills in the past could be eliminated by better application techniques. Most of the problems associated with carbofuran, too much uncovered granules left at the beginning and end of the rows and improper soil incorporation, could also hold true for other granular pesticides. Therefore, the solution is not through the cancellation of carbofuran granules, but through the development of better application equipment. FMC and Clampco Company have both been working on application equipment that has instantaneous

shut offs, which would eliminate uncovered pesticide granules which the birds pick up. Also better enforcement of placing and timing of applications would eliminate incorporation problems.

Much of the application of carbofuran at the high rate of active ingredient has nematacidal activity as well as insecticidal. If the low rate (one pound active ingredient per acre) is adopted, then carbofuran will have no nematacidal activity and the uses of other nematicides will most likely increase.

REFERENCES

______, "1985-89 Insect Control Guide". Institute of Food and Agricultural Sciences, University of Florida.

______, "1985-89 Insect Control Guide". Louisiana Cooperative Extension Service, LSU Agricultural Center, Louisiana State University Agricultural and Mechanical College.

1989. Texas Agricultural Facts. Texas Agricultural Statistics Service. Texas Department of Agriculture and USDA. Sept. 22.

1989. Texas Agricultural Facts. Texas Agricultural Statistics Service. Texas Department of Agriculture and USDA. Sept. 7.

1989. Washington Riceletter. Vol 15, No. 18.

Anon. 1983. 1982 New Jersey Orchard and Vineyard Survey. NJ Crop Reporting Service Circular 504. pp 24.

Anonymous. 1989. FIELD CROPS, Crop Production, November 13, 1989. Florida Agricultural Statistics Service, Orlando, FL.

Archer, T.E. , J.D. Stokes, R.S. Bringhurst. 1977. Fate of carbofuran (insecticide or nematicide) and its metabolites on strawberries in the environment. Jr. Agric. and Food Chem. 25(3):536-41.

Bagent, Jack. Division Leader and Specialist (Entomology). Louisiana Cooperative Extension Service.

Bernhardt, John. Research Associate. Arkansas Agricultural Experiment Station, Stuttgart.

Bollich, Pat. Rice Agronomist. Louisiana Agricultural Experiment Station, Crowley.

Bontadelli, P. 1989a. Letter from Pete Bontadelli (CDFG) to Stephen Johnson (EPA), April 17, 1989.

Bontadelli, P. 1989b. Letter from Pete Bontadelli (CDFG) to Karis North (EPA), September 18, 1989.

Bowling, C.C. 1957. Seed treatment for control of the rice water weevil. J. Econ. Entomol. 50(4):450-452.

Bowling, C.C. 1963. Effect of nitrogen levels on rice water weevil populations. J. Econ. Entomol. 56(6):826-827.

Bowling, C.C. 1963. Tests to determine varietal reaction to rice water weevil. J. Econ. Entomol. 56(6):893-894.

Bowling, C.C. 1967. Insect pests of rice in the United States. In Major Insects of the Rice Plant. Proc. Symp. Int. Rice Research Institute, Los Banos, Philippines, 1964. Johns Hopkins University Press, Baltimore, MD. pp. 551-569.

Bowling, C.C. 1968. Rice water weevil resistance to aldrin in Texas. J. Econ. Entomol. 61(4):1027-1030.

Bowling, C.C. 1972. Status of rice water weevil resistance to aldrin in Texas. J. Econ. Entomol. 65:1490.

Bowling, C.C. 1980. Breeding for host plant resistance to rice field insects in USA. In Biology and Breeding for Resistance to Anthropods and Pathogens in Agricultural Plants. TAES MP-1451. pp. 329-340.

Bowling, C.C. 1980. Insect pests of the rice plant. In Rice: Production and Utilization. Ed. B.S. Luh. AVI Publishing Company Inc. Westport, Connecticut.

Brennan, B.M. 1989. Letter to EPA regarding registration of carbofuran.

Brown, G.C., C.H. Shanks. 1976. Mortality of two-spotted spider mite predators caused by the systemic insecticide, carbofuran. Environ. Entomol. 5(6):1155-9.

Brunson, M.W. 1989. Double cropping crawfish with sorghum in Louisiana. Louisiana Agricultural Experiment Station. Bulletin 808.

Bunyarat, M., N.P. Tugwell, and R.D. Riggs. 1977. Seasonal incidence and effect of a mermithid nematode parasite on the mortality and egg production of the rice water weevil, Lissorhoptrus oryzophilus. Environ. Entomol. 6:712-714.

Cairns, John. Area Agronomy Specialist. Missouri Cooperative Extension Service, Bloomfield.

California Department of Food and Agriculture.

Campbell, W.V., D.A. Emery, J.C. Wynne, and R.W. Batts. 1976. Interaction of peanut variety and insecticides.

Carbofuran, Special Review Technical Support Document. 1989. United States Environmental Protection Agency, Office of Pesticides and Toxic Substances, Washington, D.C.

Cave, G.L., C.M. Smith, and J.F. Robinson. 1984. Population dynamics, spatial distribution and sampling of the rice water weevil on resistant and susceptible rice varieties. Environ. Entomol. 13:822-827.

Christ, E.G. 1988. How Much is Your Orchard Worth. Fruit Grower. Dec. 1988. p 16-17.

Cone, Wyatt W., 1963, Journal of Economic Entomology Vol. 56, No. 5, pp. 677 - 680.

Cone, Wyatt W., 1968, Journal of Economic Entomology, Vol., 61, No. 5, pp.1220 - 1224.

Cook, C.A., C.M. Smith, J.F. Robinson, and G.B. Trahan. 1986. Investigations of resistance in rice, Oryza sativa L., to the rice water weevil, Lissorhoptrus oryzophilus Kuschel. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 78:157.

Cooperative Extension Service, Mississippi State University.

1983. Rice Insect Control. Publication 888.

Cooperative Extension Service, Mississippi State University. 1983. Publication 1376.

Cooperative Extension Service, University of Arkansas. 1988. Rice Production Handbook. MP 192.

Cooperative Extension Service, University of Arkansas. 1987. Control of Insects Attacking Rice. EL 330.

Cram, W.T., 1962. Control of root weevils in strawberries, Canad. Dept. Agric. Public., 110, 7 pp.

Cram, W.T., 1964. Inherent tolerance in larvae of the root weevils, Sciopithes obscurus Horn and Nemocestes incomptus (Horn) to common soil insecticides. Proc. Ent. Soc. B.C., 61:27-30.

Cram, W.T., 1978. The effect of root weevils (Coleoptera: Curculionidae) on yield of five strawberry cultivars in British Columbia. Jr. Ent. Soc. B.C., 75:10-13.

Cram. W.T. and H. Andison, 1959. Soil insecticides for control of root weevil in strawberries in B.C., Can. Jr. Pl. Sci., 39:86.

Doss, R.P., C.H. Shanks, J.D. Chamberlain, J.K.L. Garth, 1987. Role of leaf hairs in resistance to a clone of beach strawberry, Fragaria chiloensis, to feeding by adult black vine weevil, Otiorhynchus sulcatus (Coleoptera: Curculionidae) Environ. Ent. 16(3):764-8.

Douglas, W.A. and J.W. Ingram. 1942. Rice field insects. U.S. Dept. Agric. Circ. 632:2-7.

Downes, W., 1931. The Strawberry Root Weevil, Canad. Dept. Agric. Pamphlet 5, N.S., 19pp.

Drees, Bart. Extension Entomologist. Texas Agricultural Extension Service, Bryan.

Eide, P.M., 1952. Soil treatments for strawberry weevil control. Proc. Western Washington Hort. Assoc., Jan. 1952: 43-7.

Eide, P.M., 1959. Soil fumigation to control weevil grubs in strawberries . Jr. Econ. Ent., 52(1):3-5.

Everett, T.E. 1966. Arthropod pests of rice fields in the United States. FAO International Rice Commission, Working Party on Rice Production and Protection.

Flickinger, E.L., C.A. Mitchell, D.H. White, and E.J. Robbe. 1986. Bird poisoning from misuse of the carbamate Furadan in a Texas rice field. Wildl. Soc. Bull. 14:59-62.

Flickinger, E.L., K.A. King, W.F. Stout, and M.M. Mohn. 1980. Wildlife hazards from Furadan 3G application to rice in Texas. J. Wildl. Manage. 44(1):190-197.

Gerlow, Art. Extension Economist-Management. Texas Agricultural Extension Service, Bryan.

Gifford, J.R., B.F. Oliver, and B.B. Trahan. 1975. Rice water weevil with pirimiphos ethyl seed treatment. J. Econ. Entomol. 68:79-81.

Gifford, J.R. and G.B. Trahan. 1968. Progress on screening rice varieties for resistance to rice water weevil. Proc. Rice Technical Working Group. 12:54.

Gifford, J.R. and G.B. Trahan. 1976. Host plant resistance to stem borer and rice water weevil. Proc. Rice Technical Working Group. 16:63.

Gray, Leroy. Extension Fisheries Specialist. Cooperative Extension Service, University of Arkansas, Little Rock.

Grigarick, A., J. Lynch, M. Oraze, and K. Smith. 1984. Effect of varying water levels on the maturation of rice water weevil eggs in the rice plant. Proc. Rice Technical Working Group. 20:69.

Grigarick, A., M. Oraze, and K. Smith. 1986. Comparative growth characteristics of and rice water weevil development on a susceptible and two tolerant cultivars of rice. Proc. Rice Technical Working Group. 21:92-93.

Grigarick, A.A. 1964. The rice water weevil in California. Proc. Rice Technical Working Group. 10:40-41.

Grigarick, A.A. 1970. Economic injury by the rice water weevil in California and the relationship of injury to the field margins. Proc. Rice Technical Working Group. 13:26.

Grigarick, A.A. 1974. Rice variety tolerance to the rice water weevil in California. Proc. Rice Technical Working Group. 15:43-44.

Grigarick, A.A. 1984. General problems with rice invertebrate pests and their control in the United States. Protection Ecology. 7:105-114.

Grigarick, A.A., M.J. Oraze, and K.A. Smith. 1988. A comparison of greenhouse and field studies on rice water weevil tolerance. Proc. Rice Technical Working Group. 22:78-79.

Grigarick, A.A., M.O. Way, and S.L. Clement. 1976. Results of rice variety tolerance tests to the rice water weevil in California. Proc. Rice Technical Working Group. 16:63-64.

Grigarick, A.A. and G.W. Beards. 1965. Ovipositional habits of the rice water weevil in California as related to a greenhouse evaluation of seed treatments. J. Econ. Entomol. 58:1053-1056.

Grigarick, A.A. and M.O. Way. 1980. The relationship of adult feeding scars of the rice water weevil to rice yields. Proc. Rice Technical Working Group. 18:51-52.

Grigarick, A.A. and M.O. Way. 1982. Evaluating tolerance of water-sown rice to the rice water weevil. Proc. Rice Technical Working Group. 19:44.

Grigarick, A.A. Professor of Entomology. Department of Entomology, University of California, Davis.

Guad, S.M., J.G. Tuduri, L.F. Martorell and J.C. Rodriguez 1974. Preliminary screening of pesticides for control of banana root borer, Cosmopolies sordidius Germar, (Colesptera:Curculionidae). J. Agric. Univ. of Puerto Rico. 58:79-81

Hamill, James. Professor of Agricultural Economics. Mississippi State University, Starkville.

Hancock, J.F., and D.H. Scott, 1988. Strawberry cultivars and worldwide patterns of strawberry production. Fruit Varieties Journal. 42(3):102-8.

Hawaii Department of Agriculture 1988. Statistics of Hawaiian Agriculture 1987. p. 42

Hill, Jim. Rice Extension Specialist. University of California, Davis.

Hotchkiss, B.E., et. al. 1989. Extoxnet, Extension Toxicology Network. Cornell University, Ithaca, NY.

Huey, Bobby. Rice Extension Specialist. Arkansas Agricultural Extension Service, Stuttgart.

Ingram, J.W. 1927. Insects injurious to the rice crop. U.S. Dept. Agric. Farmers Bull. 1543:1-4.

Isley, D. and H.H. Schwardt. 1934. The rice water weevil. Ark. Agric. Expt. Stn. Bull. 299.

Johnson, Albert W. and Donald G. Manley. 1982. Parasitism of tobacco budworm on tobacco in South Carolina. J. Georgia Entomol. Soc. 18:1-6.

Johnson, C.W. and H.L. Carnahan. 1982. Breeding rice for tolerance to the rice water weevil (Lissorhoptrus oryzophilus Kuschel). Proc. Rice Technical Working Group. 19:45.

Johnson, Freddie. 1989. Personal communication, January, 1989 -August, 1989. Extension Entomologist, University of Florida, Gainesville, Florida.

Jones, David. Rice Agronomist. University of Florida, Belle Glade.

Kitagawa, Y. 1989. Letter to EPA regarding registrations of carbofuran.

Klosterboer, Arlen. Agronomy Specialist. Texas Agricultural Extension Service, Beaumont.

Latson, L.N., J.R. Gifford, and G.B. Trahan. 1976. Evaluation for resistance in rice to the rice water weevil and the rice stink bug. Proc. Rice Technical Working Group. 16:62.

Lauck, J.E. 1972. Host relationships and impact of herbicide treatments on population fluctuations of the rice water weevil. Proc. Rice Technical Working Group. 14:51.

Linscombe, Steve. Associate Specialist (Rice Agronomy). Louisiana Cooperative Extension Service, Crowley.

Littrell, E. E. 1988. Waterfowl mortality in rice fields treated with the carbamate, Carbofuran. Calif. Fish & Game 74(4):226-231.

Littrell, E.E. 1988. Waterfowl mortality in rice fields treated with the carbamate, carbofuran. California Fish and Game. 74(4):226-231.

Louisiana State University Agricultural Center. 1987. Rice Production Handbook. Publication 2321.

Lynch, R. E., J. W. Garner, and L. W. Morgan. 1984. Influence of systemic insecticides on thrips damage and yield of Florunner peanuts in Georgia. J. Agric. Entomol. 1 (1):33-42.

Magee, R. 1989. Letter from Rex Magee (CDFA) to Stephen Johnson (EPA), March 16, 1989.

Mau, R.F.L. 1981. The banana root borer, a new pest. Entomology Notes No. 11, Hawaii Cooperative Extension Service. 4pp.

McCalley, N.F., and N. C. Welch, 1978. Furadan controls root weevil on strawberries. Calif. Agric. 32(6):16-17.

Melander, A.L. and A. Spuler, 1926. Poisoned baits for strawberry root weevil. Washington Agric. Expt. Sta. Bull. 199, 22 pp.

Miller, Ted. Rice Extension Specialist. Mississippi Cooperative Extension Service, Stoneville.

Morgan, D.R., N.P. Tugwell, and P.H. Slaymaker. 1982. Spring emergence of the rice water weevil and degree-day accumulations. Proc. Rice Technical Working Group. 19:46-47.

Morgan, D.R., P.H. Slaymaker, J.F. Robinson, and N.P. Tugwell. 1984. Rice water weevil (Coleoptera: Curculionidae) indirect flight muscle development and spring emergence in response to temperatures. Environ. Entomol. 13:26-28.

Morgan, Ruth. Pesticide Coordinator Extension Entomologist. Mississippi State University, Starkville.

Mote, Don. C. and Joseph Wilcox, 1927. The strawberry root weevils and their control in Oregon. Oregon Agricultural College, Experiment Station Circular 79, 24 pp.

Newsom, L.D., and M.C. Swanson. 1962. Treat seed to stop rice water weevil damage. La. Agric. 5:4-5.

Nickle, W.R. 1984. Plant and Insect Nematodes. Dekker, Inc. New York. 925 pp.

Nielson, D.G., 1975. Black Vine Weevil: Resistance to dieldrin and sensitivity to organophosphate and carbamate insecticides. Jr. Econ. Ent. 68:291.

Nowick, E.M., J.F. Robinson, C.M. Smith, H. Hoffpauir, G. Trahan, and R. Michot. 1984. Development of rice water weevil resistant germplasm. Ann. Prog. Rpt., Rice Res. Sta., La Agri. Exp. Stn., L.S.U. Agric. Ctr. 76:48-50.

Nowick, E.M., J.F. Robinson, H. Hoffpauir, and G.B. Trahan. 1983. Screening of Oryza spp. for rice water weevil resistance. Ann. Prog. Rpt., Rice Res. Sta., La. Agric. Exp. Stn., L.S.U. Agric. Ctr. 75:40-41.

Nylander, Pete. Special Agent for United States Fish and Wildlife Service. Beaumont, TX.

Oliver, B.F., J.R. Gifford, and G.B. Trahan. 1969. Varietal evaluation for resistance to the rice water weevil. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 61:155-157.

Oliver, B.F., J.R. Gifford, and G.B. Trahan. 1970. Host plant resistance research on the rice water weevil. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 62:156-163.

Oliver, B.F., J.R. Gifford, and G.B. Trahan. 1971. Differential dry weights of rice lines after supporting rice water weevil populations. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 63:181-185.

Oliver, B.F., J.R. Gifford, and G.B. Trahan. 1971. Research for rice lines resistant to the rice water weevil. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 63:176-180.

Oliver, B.F., J.R. Gifford, and G.B. Trahan. 1972. Rice water weevil host plant resistance studies. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 64:199-206.

Oliver, B.F., J.R. Gifford, and G.B. Trahan. 1972. Studies on the difference in root volume and dry root weight of rice lines where rice water weevil larvae were controlled and not controlled. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 64:212-217.

Osteen, Craig, and Fred Kuchler. Potential Bans of Corn and Soybean Pesticides: Economic Implications for Farmers and Consumers. AER-546. U.S. Dept. Agr., Econ. Res. Serv., Apr. 1986.

Pearson, R.C., R.C. Seem, and S.P. Eisensmith, 1984, Assessment of Pests, Losses They Cause and Pest Management Strategies for Great Lakes Eastern Grapes, New York Stage Agricultural Experiment Station, Geneva, N.Y., 14456.

Penman, D.R. and R.R. Scott, 1976. Impact of black vine weevil O. sulcatus (F.) on black current and strawberries in Canterbury, N.Z. N.Z. Jr. Exp. Agric. 4:381.

Pollet, Dale K., T. E. Reagan and Wm. White. February, 1982, "Pest Management of Sugarcane Insects". Louisiana Cooperative Extension Service Bulletin, Number 1982. Louisiana State University, Revised, 1989.

Pritts, Marvin, 1989. Beyond the horizon. Amer. Agriculturalist. January :24.

Raksararat, P. and N.P. Tugwell. 1975. Effect of temperature on development of rice water weevil eggs. Environ. Entomol. 4:453-454.

Reddington, Mary. Agribusiness and Public Affairs Manager. FMC Corporation. Philadelphia, PA.

Reed, Roy. Area Extension Entomologist. Mississippi Cooperative Extension Service, Stoneville.

Ring, Dennis. 1988. Personal communication, June 1988. Extension Entomologist, Texas Agricultural and Mechanical College, Texas A & M University, College Station, Texas.

Rister, Edward. Associate Professor of Agricultural Economics. Department of Agricultural Economics, Texas A&M University, College Station.

Robinson, John. Resident Director. Arkansas Agricultural Experiment Station, Stuttgart. (formerly U.S.D.A. Rice Research Entomologist, Crowley, LA).

Robinson, J.F., C.M. Smith, and G.B. Trahan. 1978. Rice water weevil host plant resistance studies. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 70:155-167.

Robinson, J.F., C.M. Smith, and G.B. Trahan. 1979. Rice water weevil host plant resistance evaluations. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 71:113-122.

Robinson, J.F., C.M. Smith, and G.B. Trahan. 1980. Rice water weevil host plant resistance: Preliminary and advanced insect resistance nurseries. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 72:193-196.

Robinson, J.F., C.M. Smith, and G.B. Trahan. 1980. Rice water weevil host plant resistance: P.I. evaluation. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 72:197-199.

Robinson, J.F., C.M. Smith, and G.B. Trahan. 1980. Rice water weevil: Water management as a cultural control method. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 72:204-211.

Robinson, J.F., C.M. Smith, G.B. Trahan, and R.J. Michot. 1984. Rice water weevil plant resistance: Beaumont lines evaluation. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 76:186-187.

Robinson, J.F., E.M. Norwick, H. Hoffpauir, and G.B. Trahan. 1984. Screening of <u>Oryza</u> spp. for rice water weevil

resistance. Ann. Prog. Rpt., Rice Res. Stn., L.S.U. Agric. Ctr. 76:201-202.

Robinson, J.F. and C.M. Smith. 1986. Rice water weevil: plant resistance evaluations. Proc. Rice Technical Working Group. 21:91-92.

Rodriquez-Kabana, R., P.G. Mawhinney, and P.S. King. 1980. Efficacy of planting time injections to soil of liquid formulations of three systemic nematicides against rootknot nematodes in peanuts. Nematropica 10:45-49.

Rolston, L.H., R. Mayes and Y.H. Bang. 1965. Aldrin resistance in the rice water weevil. Ark. Farm Res. Nov-Dec.

Roman, J., D. Oramas, J. Green and A. Torres 1983. Control of nematodes and black weevils in plantain. J. Agric. Univ. of Puerto Rico 67:270-277.

Rosentsteil, R. G., 1972. Control of young larvae of the rough strawberry weevil with carbofuran. Jr. Econ. Ent. 65(3):881.

Rouse, P. and L.H. Rolston. 1964. Some factors influencing larval infestations of the rice water weevil. J. Kan. Ent. Soc. 37(1).

Rutger, J.N. and D.M. Brandon. 1981. California rice culture. Scientific American. Feb. pp. 42-51.

Rutherform, T.A. D. Trotter, J.M. Webster, 1987. The potential of Heterorhabitid nematodes control agents of root weevils. Can. Ent. 119:67-73.

Samal, H. H. & S. R. Johnson. 1973 "Effect of Some Soil Pesticides on Sugarcane Yields in Florida". Proceedings American Society of Sugarcane Technologists. 1972. Meetings. Volume 2.

Sasser, J.N., K.R. Barker, and L.A. Nelson. 1975. Chemical soil treatment for nematode control of peanut and soybean. Plant Dis. Rep. 59:154-155.

Scardacci, Steven. Farm Advisor. Colusa Co., California.

Schaefers, G.A., 1981. Pest management systems for strawberry insects. IN, Handbook of pest management in agriculture. Vol. 3. Ed. D. Pimentel. CRC Press:377-93.

Shanks, Carl H., 1970. Insecticide tests against Brachvrhinus ovatus and B. sulcatus., Jr. Econ. Ent. 63(5):1684-5.

Shanks, Carl H., D.L. Chase, J.D. Chamberlain, 1984. Resistance of clones of wild strawberry Fragaria chiloensis to adult Otiorhvnchus sulcatus and O. ovatus. (Coleoptera: Curculionidae) Environ. Ent. 13:1042-5.

Shanks, Carl. H. 1976. Root weevils on berry crops. Washington State Coop. Ext. Circ. EM 4066, 3 pp.

Shanks, Carl. H. and R.P. Doss, 1986. Black vine weevil

(Coleoptera: Curculionidae) feeding and oviposition on leaves of weevil-resistant and susceptible strawberry clones presented in various quantities. Environ. Ent. 15:1024-7.

Schaub, James D., and Bruce Wendland. Peanuts: Background for 1990 Farm Legislation. Staff Report AGES89-61. U.S. Dept. Agr., Econ. Res. Serv., Nov. 1989.

Slingerland, M.V. and C.R. Crosby, 1914, Manual of Fruit Insects, The MacMillan Co., N.Y.

Smith, C.M., J.F. Robinson, and G.B. Trahan. 1982. Screening for plant resistance to the rice water weevil. Proc. Rice Technical Working Group. 19:43.

Smith, C.M. and J.F. Robinson. 1982. Evaluation of North american rice cultivars for resistance to the rice water weevil. Environ. Entomol. 11:334-336.

Smith, C.M. and J.F. Robinson. 1984. Progress in identification of rice genotypes with rice water weevil resistance. Proc. Rice Technical Working Group. 20:73.

Smith, J. C. 1976. Peanut injury and Southern Corn Rootworm. Chemical control. Suffolk, 1975. Insecticide and Acaracide Test. 1:94-95.

Smith, J. W., Jr. and R. L. Sams. 1977. Economics of thrips control on peanuts in Texas. Southwestern Entomologist. Vol 2 (3):149-154.

Smith, K.A., A.A. Grigarick, J.H. Lynch, and M.J. Oraze. 1985. Effect of alsystin and diflubenzuron on the rice water weevil. J. Econ. Entomol. 78:185-189.

Smith. F.F., 1932. Biology and control of black vine weevil. U.S.D.A. Tech. Bull. 325, 45 pp.

Sooksai, S. and P. Tugwell. 1976. Adult rice water weevil feeding scars: Distribution in rice field, seasonal pattern and correlation with larval stage of weevil. Proc. Rice Technical Working Group. 16:58-59.

Soybeans, Iowa's Premiere Crop. A Handbook of Soy Information. Iowa Soybean Association, Iowa Soybean Promotion Board, 1200-35th Street, No. 502, West Des Moines, IA 50265.

Stansel, J.W. Resident Director. Texas Agricultural Experiment Station, Beaumont, TX.

Tappan, W. B. and D. W. Gorbet. 1981. Economics of tobacco thrips control with systemic pesticides on Florunner peanuts in Florida. J. Econ. Entomol. 74:283-286.

Texas Agricultural Experiment Station. 1975. Six Decades of Rice Research in Texas. Research Monograph 4.

Texas Agricultural Extension Service. 1989. Rice Production Guidelines. D-1263.

Tugwell, N.P. and F.M. Stephen. 1981. Rice water weevil seasonal abundance, economic levels, and sequential sampling plans. University of Arkansas Agricultural Experiment Station. B-849.

Tugwell, Phil. Professor of Entomology. Department of Entomology, University of Arkansas, Fayetteville.

Tugwell, P. and R. Thompson. 1968. Results of 1967 mangement practices and insecticide tests designed to reduce rice water weevil injury. Proc. Rice Technical Working Group. 12:51-52.

University of California Statewide Integrated Pest Management Project. 1983. Integrated Pest Management for Rice. Publication 3280.

USDA. 1987. Agricultural Statistics. pp. 19-28.

USDA. August, 1986. Crop Production, 1986. Summary, ASB, NASS, Number CrPr2-1(88).

Way, M.O. Associate Professor of Entomology. Texas Agricultural Experiment Station, Beaumont.

Way, M.O. and R.G. Wallace. 1984. Spatial distribution of adult rice water weevil feeding scars in Texas. Proc. Rice Technical Working Group. 20:70.

Way, M.O. and R.G. Wallace. 1986. Resistance of Texas rice varieties to the rice water weevil, Lissorhoptrus oryzophilus Kuschel. Texas Agricultural Experiment Station. PR-4367.

Way, M.O. and R.G. Wallace. 1988. Susceptibility of selected Texas rice genotypes to the rice water weevil 1986-1987. Texas Agricultural Experiment Station. PR-4563.

Wick, Carl. Farm Advisor. Buttte Co., California.

Williams, Jack. Farm Advisor, Sutter Co., California.

Woodruff, R.E. 1969. The banana root borer. (Cosmopolites sordidus (Germar)), in Florida (Coleoptera:Curculionidae). Entomol. Circ. 88 Florida Dept. of Agric. 2 pp.

Wright, W.E. 1977. Insecticides for the control of dieldrin-resistant banana weevil borer, (Cosmopolites sordidus (Germar)). Aust. J. Exptl. Agric. Animal Husbandry 17:499-504.

APPENDIX I

PIAP SURVEY

Pesticide Under Review_______________ Target Pest(s):_______________

Crop/Site_______________ State(s):_______________ Date:_______________

Acreage Planted	Production Unit	Unit Yield per Acre	Avg. Price per Unit	Acreage Trt. with Subject (%)	Avg. Treatment Rate/Acre (oz. a.i.)

Applications per Trt. Acre (No.)	Avg. Cost / oz. a.i.: ($)	Appl. Cost / Acre ($)	Avg. Cost of Treatment ($/Ac)	Is application cost intrinsic to operation?
				Circle Option: YES or NO

Changes in application that would affect triggers:

Chemical or Non-Chem Alts. Available as Replacements	Trt. Area (%)	Subj. Pest. Replmt.	Alt. Chem. Rate / Ac. (oz. a.i)	Avg. No. Trt. Needed per Acre	Cost Per Treatment ($/Ac)	Effect on Quality	Applic. Methods	Relative Efficacy

Estimate % loss or gain/acre if subject pesticide withdrawn. %

Comments on alternatives:

Name of Respondent:
Institution & Address:

Phone:

PIAP SURVEY FORM INSTRUCTIONS

This survey form is designed for collection of pesticide impact assessment data for a given pesticide that is subject to review for reregistration. The format is set up for pesticides used on crop plants for which production statistics and treatments are expressed on a per acre basis. For other situations, make adjustments as needed and indicate the units of measure used.

The following instructions provide clarification on data needed, all headings not be applicable to a particular crop/site.

<u>Acreage Planted:</u> Applies to total planted crop acreage applicable to state or regional specified.

<u>Production Unit:</u> Use units of production commonly used by the crop reporting service (bu., tons, etc.).

<u>Unit Yield per Acre:</u> Provide average over the past 3 to 5 years.

<u>Average Price per Unit:</u> Should represent average price received by growers per specified unit of production over past 3 to 5 years.

<u>Acreage Treated with Subject Pesticide (%):</u> Applies to acres treated by subject pesticide under review. Express as percentage of acreage planted. If answer is 0, please provide information below on chemical or non-chemical alternatives used instead of the subject pesticide.

<u>Average Treatment Rate / Acre:</u> Indicate the average amount active ingredient of the subject pesticide that is applied per treatment per acre.

<u>Applications per Treated Acre (Number):</u> Indicate average number of applications of the subject pesticide applied to an area during a growing season.

<u>Average Cost / ounce active ingredient:</u> Provide best estimate of average cost of the subject pesticide expressed in ounces actual ingredient.

<u>Application Cost / Acre:</u> Provide best estimate of application costs (not including cost of pesticide) if applicable.

<u>Average Cost of Treatment ($/Acre):</u> Provide best estimate of the cost of a single treatment including application cost if applicable.

<u>Is application cost intrinsic to operation (Yes or No):</u> Indicate whether use of the subject pesticide requires an application expense. An intrinsic application cost would be incurred regardless of whether the pesticide was applied, due to normal farm operations.

<u>Changes in application that would affect triggers:</u> Note any change in application practices that would alter conditions that triggered review of subject pesticide.

<u>Chemical or Non-Chemical Alternatives Available to Replace Subject Pesticide:</u> List alternative labeled treatments or non-chemical practices that can be used in place of the subject pesticide under review.

<u>Treated Area (%):</u> Indicate the proportion of the crop acreage currently using the alternative.

<u>Subject Area Replacement (%):</u> Indicate the proportion of the crop acreage currently receiving the subject pesticide that could instead be treated with the alternative treatment or practice.

<u>Alternative Chemical Rate / Acre (ounces active ingredient):</u> Indicate average amount active ingredient of the alternative chemical that would be used per acre per treatment to replace the subject pesticide. Leave blank where alternative practice does not include a per acre treatment (e.g. cultural practice).

<u>Average Number Treatments per Acre:</u> Indicate the number treatments per acre required if the alternative pesticide is used to replace the subject pesticide.

<u>Cost per Treatment / Acre ($/Acre):</u> Provide best estimate of the cost of a single treatment of the chemical or non-chemical alternative, including application costs if applicable.

<u>Effect on Quality:</u> Note any effect on quality anticipated (phytotoxicity, finish, molds, etc.) from use of the alternative.

<u>Application methods:</u> Note relevant methods of application of alternative (air, ground, chemigation, etc.)

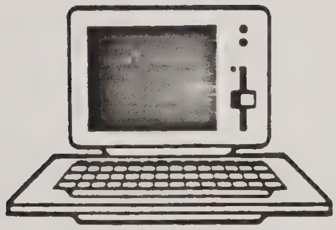
<u>Relative Efficacy:</u> Note effectiveness of the alternative relative to the subject pesticide.

<u>Estimate % loss or gain per acre if subject pesticide withdrawn:</u> Provide best estimate on production loss or gain that may result if subject pesticide under review is withdrawn from use.

<u>Name, Institution & Phone Number:</u> Respondent should provide full information for follow-up questioning if needed.

APPENDIX II

Extension Circular #150



Furadan Assessment

A Computer Model

by

H. Don Tilmon, Ph. D.
Farm Management Specialist

Frank B. Dilley
Programmer

Delaware Cooperative Extension
University of Delaware
Newark, Delaware 19717

June 1, 1989

Furadan Assessment requires an IBM-PC, or a fully compatible computer, running PC/MS-DOS 2.0 or higher. A color monitor is not required.

Extension Circular #150

Furadan Assessment

A Computer Model

by
H. Don Tilmon, Ph. D.
Farm Management Specialist

Frank B. Dilley
Programmer

Delaware Cooperative Extension
University of Delaware
Newark, Delaware 19717

June 1, 1989

Table of Contents

FURADAN ASSESSMENT

The computer model discussed in the following manual was designed to analyze the economic impact of deleting Carbofuran from the arsenal of pesticides currently used by the farmers of America. In addition to Carbofuran, the subsequent deletion of additional pesticides is also considered.

The model is designed to utilize data furnished by state extension specialists from around the United States who work specifically with the crops and pests in question. Presumably, these individuals constitute the most accurate source of impartial information available, short of a nationwide survey of every crop in question. The results of the model should be interpreted accordingly.

The Model:

The computer model is a compiled basic program of nine screens. Of these nine screens, the main program is in a loop consisting of four input and one output screen. In order to run the program, boot up your IBM PC or compatible to the A:> prompt, place the disk in drive A:, and type FURADAN. (It does not have to be in caps.) A disclaimer similar to the one below will appear on the first screen. At this point hit the F1 key to move to the next screen.

Figure 1: Disclaimer Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING

FURADAN ASSESSMENT

A computer analysis of the economic effect on agriculture from the elimination or restriction of the registration on carbofuran by the Environmental Protection Agency.

The costs provided are the best estimates available for the intended purpose and should be recognized as NOT being the result of a scientific survey. The order of subsequent deletion of chemicals after Furadan is done at the discretion of the operator of this program.

1-NEXT 3-QUIT UNIVERSITY OF DELAWARE EXTENSION SYSTEM

Upon pressing the F1 key, the screen below will appear. If you have previously run the program and have saved information that you would now like to review, type in the name of the saved file to retrieve that information. Please note that you must add the three letter extension to the file name in order to retrieve the data. After typing in the file name press, the return key to move to the next screen.

Figure 2: Recall Saved File Data Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING

You may enter the name of a file of saved data or press the carriage return key to run with new data: cornro.del

If you do not wish to retrieve an old file, but instead would like to run with new data, press the return key without typing any information and move to the next screen.

Upon pressing the return key, a screen similar to the following one will appear. The cursor should be in the first input field to receive the name of the state for which the current analysis is being run. After typing in the name of the state, hit the carriage return key to record the information and move to the next input field. (Note: No information will be recorded if you do not hit the return key. This is particularly true for the last input field on the screen as you hit F1 to move to the next screen.)

Continue entering data on the first input screen until all input fields have been filled. If you make an input error, continue on through the fields and the cursor will cycle back to the top. You can continue pressing the return key until you arrive back at the field you wish to correct. Type in the change and be sure to hit the return key.

Figure 3: Pest/Crop Information Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING Pest/Crop Information

FURADAN ASSESSMENT

Analysis for the State of: DELAWARE

Crop: CORN Ave. Yield: 115 / BU (units)

Ave. Price: $2.75 Acres Planted: 148000

Pest (complex): ROOTWORM Acres Treated: 15000

1-NEXT 3-QUIT UNIVERSITY OF DELAWARE EXTENSION SYSTEM

When you are satisfied with all the information on the screen, hit F1 to move to the second input screen. An "*" will appear in the upper right corner of the screen to indicate that the information on the screen is being saved for printing if you wish to have a hard copy of the data and results at the end of the run. This screen, similar to the one below, allows for additional chemicals to be added to the list of those considered, the adjustment of prices of all chemicals listed ($ Price per ounce active ingredient), and a reordering of the chemicals as they might be deleted from the registration list for the crop/pest under analysis.

Figure 4: Prices & Deletion Order Input Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING Prices & Deletion Order

Chemical	Price per unit active	Deletion order
FURADAN 4F	.78	1
Lorsban 4E	.56	5
Dyfonate	1.87	
Mocap 6E	.43	4
Telone II	.34	
Di-Syston 15-G	.71	2
Diazinon	.50	3
Temik 15G	.17	

1-NEXT 3-QUIT UNIVERSITY OF DELAWARE EXTENSION SYSTEM

The deletion ordering of chemicals should start with FURADAN as the first and continue through four additional compounds. Only five pesticides will be carried forward to the next screen. **(Again, be sure to hit the return key after each entry to record the data.)**

After all data is entered, hit F1 to move to the third input screen. The third screen, similar to the one below, allows you to enter the current control program on those total acres which you indicated previously on input screen one were <u>treated</u> for this pest. Please note that the "% Acres Treated" column should add to 100% unless there are some acreages that are treated with chemicals other than the five we are considering in this analysis. The model will flag you on the next screen if this column does not add to 100%, but the program will continue if you ignore the flag.

Figure 5: Current Program (Cost Input) Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING Current Program

Chemical	% Acres Treated	Total a.i./A	Total Treat/yr	Applic- $/Trip	Quality Adjust	Yield Adjust
FURADAN 4F	20	16	1	5		15
Di-Syston 15-G	30	14	1	5		10
Diazinon	15	16	1	5		15
Mocap 6E	15	8	1	5		10
Lorsban 4E	20	16	1	5		15

1-NEXT 3-QUIT UNIVERSITY OF DELAWARE EXTENSION SYSTEM

In the "Total Active Ingredient / Acre" column, you should make your entry consistent with the price information you entered on screen two. If you priced the compounds on a pound basis, be sure to enter the rate per acre on a pound basis. If the prices were entered on an ounce basis, be consistent here. Please note that you need to enter the total amount of active ingredient that will be applied in all applications for this pest. This value will be multiplied by the price per unit from the previous screen and stored as a negative number to represent a <u>cost</u>. Added to this cost of ingredient will be the product of the "Total Treatments / Year" times the "Application $ / Trip" across the field. (This is also an negative number.)

If the pest injury to the crop, if the pest were left untreated, would result in a decrease in quality of the commodity, a percentage quality adjustment (no decimal is needed) should be entered as a whole number in the "Quality Adjust" column. The program will convert to a percent and multiply that times the average yield from screen one to get the estimated benefit from the use of the pesticide. If the pest injury to the crop would have resulted in a direct yield loss, enter that number in the "Yield Adjust" column. If both a quality and an actual yield loss might occur, put a number in both columns. The value of these adjustments (i.e. yield X price) is then <u>added back</u> under the assumption that this is the yield and/or quality that is being preserved by the use of this pesticide.

After all data is entered, hit F1 to move to the fourth and final input screen.

Figure 6: Deletion of Chemicals Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING   Deletion of Chemicals

Chemicals	Current % Acres Treated	Redist. A. for Chem 1 Removed	Chem 2 Removed	Chem 3 Removed	Chem 4 Removed	Chem 5 Removed
FURADAN 4F	20	0				
Di-Syston 15-G	30	40	0			
Diazinon	15	20	40	0		
Mocap 6E	15	20	30	50	0	
Lorsban 4E	20	20	30	50	100	0

1-NEXT   3-QUIT   UNIVERSITY OF DELAWARE EXTENSION SYSTEM

On the fourth screen we "Re-distribute" the acreage as the result of deleting the first and subsequent pesticides. (Note: If the "Current % Acres Treated" column did not add to 100% the cursor will start in that column to give you a chance to adjust the current program.) Assuming that FURADAN was the first pesticide deleted, you would then distribute the percentage of acres that was in FURADAN among the other pesticides. No decimals are necessary on this screen. When satisfied with the information on this screen, hit F1 to move to the final screen.

The final screen, such as the one shown below, is an output screen summarizing the input and analyses of the previous four screens. The "Net Benefit from Application" is the per acre values that reflect the cost of the pesticide and the cost of its

Figure 7: Acre / State Economics (Output) Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING Acre / State Economics

Total Revenue Change As Chemicals Are Deleted On
CORN FOR ROOTWORM IN DELAWARE.

Chemical	Net Benefit from Ap-plicaton	Quality/ Yield Adj from Deletion	Per Acre Change from Del.	Total Revenue Change for State from Deletion
FURADAN 4F	23.77	-11250 BU	-1.13	-16950
Di-Syston 15-G	12.56	22500 BU	5.26	78900
Diazinon	28.25	-15000 BU	-2.03	-30450
Mocap 6E	19.06	37500 BU	4.11	61650
Lorsban 4E	27.29	-225000BU	-27.29	-409350

1-NEXT 3-QUIT UNIVERSITY OF DELAWARE EXTENSION SYSTEM

application, adjusted by the yield and/or quality enhancement resulting from the application of that particular pesticide. A positive figure in this column indicates that the pesticide is returning more to the grower that it is costing him - all other things constant. The relative values in this column allow the comparison of relative efficacy vs. cost of the five compounds in this particular analysis.

The column headed by "Quality / Yield Adjustment from Deletion" reflects the total quality and/or yield adjustment that results when the compound in question is deleted from use. A negative value here indicates that those compounds replacing a deleted compound are relatively less efficient and that the total crop for the state is thus reduced by the amount indicated. A positive value in this column indicates that yields are greater when the alternative compounds are used to replace the one deleted. It should be noted that this column does not include any of the relative costs associated with application.

The "Per Acre Change from Deletion" is the <u>weighted-adjusted</u> change per acre in net revenue from the deletion of the compound in question as calculated by the effects of the re-distributed acres . The final column represents the total dollar change in net revenue for the state for the <u>infested</u> acreage of the crop in question. A negative value in the last two columns indicates the amount by which the growers of this crop in this state will in general be worse off by this much if the compound is deleted. A positive value indicates that the job of controlling pests could be done better by the other alternative controls.

Run Options:

After reviewing the results of your analysis, press F1 to move to the next screen which contains a menu such as the one shown below. If the results were unsatisfactory, you may recycle through the analysis by placing an "X" in the first box, pressing the return key to record the data, and then pressing F1. The program will cycle back to the first input screen, retaining all the input from the previous run. By moving through the input fields with the return key and moving from screen to screen with the F1 key, you can review the data and make corrections where appropriate to adjust the analysis for the pest and state in question.

Figure 8: Run Options Menu Screen.

```
CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING        Run Options Menu

             Please select one or more options:

                Rerun same data to further modify

             X  Print hard copy output

             X  Save data from this run in file and add it to summary file

1-NEXT              3-QUIT              UNIVERSITY OF DELAWARE EXTENSION SYSTEM
```

If you are satisfied with the analysis when you reach the "Run Options Menu", you may place an "X" in the second box to print a hard copy of the output and/or an "X" in the third box to save the data in a unique file and also add the information to a summary file. The summary file accumulates the yield adjustments and revenue changes associated with individual compounds as well as a running total acreage planted and acreage treated for a given crop. (For an example of the summary file, see APPENDIX B) After pressing the return key to record the X(s), hit F1 to move to the next screen.

A decision screen such as the one shown below will appear. The unique file that was created when the final box was checked is named automatically in the following manner. The first five letters of the crop name become the first five letters of the file name. To these five letters are added the first two letters of the pest name. Finally, the state name furnishes the

extension to the file name. A five inch floppy disk should have enough space for the entire program and at least forty individual analyses, as well as the summary file. (More, of course, can be stored on the 3.5 inch disks.)

Figure 9: File Naming Screen.

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING

CORNRO.DEL saved.

Enter a file name here ONLY IF YOU ARE DONE
and would like to save a summary of the run.
Press <ENTER> to enter more data:

1-NEXT 3-QUIT UNIVERSITY OF DELAWARE EXTENSION SYSTEM

If you wish to analyze additional states, press the return key to cycle back to input screen number one. The data from the previous run will be displayed for your modification. Hopefully this will reduce the amount of data input needed for the next state or pest.

If, on the other hand, all desired analyses have been completed, you may exit the program by naming the summary file with a name of you own choosing. Type in the file name and press the return key. The program will save the summary file, name it, and end.

Printing:

The hard copy printing of an individual analysis was discussed above. If you did not print a copy of an individual run and wish to do so at a later date, re-run the FURADAN program. On the second screen from the beginning, enter the name of the file of saved data you wish to print, cycle through to the "Run Options Menu" screen, and check the second box. In this way you can print a hard copy of the individual analysis.

To print a copy of the summary file, the following procedure should generally work. For a computer with two floppy disks, place the DOS disk in drive A:, the disk containing the summary file in drive B:, and at the A:> prompt type in:

```
A:>\PRINT B:fname
```

If the computer comes back and asks the name of the 'list device' you can usually continue and print the file by simply pressing the return key.

For the computer with a hard disk, at the C:> prompt, place the disk containing the summary file in drive A:, and type in:

```
C:>\PRINT A:fname
```

In either case, if you named the file with an extension, that extension must be added to the file name.

<u>Modifying the DATA.DAT file:</u>

The FURADAN program accesses a data file of compound names and prices. The file name is DATA.DAT. This file can be modified with any word processing software that reads and writes ASCII files. (Word Perfect versions later than 4.2 may require the use of "Text In/Out" command to read and save the DATA.DAT file in ASCII format.) The number at the top of the file refers to the number of pairs of data. Be sure to maintain the appropriate placement of " " marks and commas. The following is an example of the DATA.DAT file:

```
8
"FURADAN 4F",".78"
"Lorsban 4E",".56"
"Vydate L","6.25"
"Mocap 6E",".43"
"Telone II",".34"
"Telone C-17",".71"
"Nemacur 3",".96"
"Temik 15G","1.25"
^Z
```

APPENDIX A

Individual Analysis - Hard Copy Example

FURADAN ASSESSMENT

Analysis for the State of: DELAWARE

Crop: CORN Ave. Yield: 115 / BU (units)

Ave. Price: $2.75 Acres Planted: 148000

Pest (complex): ROOTWORM Acres Treated: 15000

Chemical	Price per unit active	Deletion order
FURADAN 4F	.78	1
Lorsban 4E	.56	5
Dyfonate	1.87	
Mocap 6E	.43	4
Telone II	.34	
Di-Syston 15-G	.71	2
Diazinon	.50	3
Temik 15G	.17	

Chemical	% Acres Treated	Total a.i./A	Total Treat/yr	Applic-$/Trip	Quality Adjust	Yield Adjust
FURADAN 4F	20	16	1	5		15
Di-Syston 15-G	30	14	1	5		10
Diazinon	15	16	1	5		15
Mocap 6E	15	8	1	5		10
Lorsban 4E	20	16	1	5		15

Chemicals	Current % Acres Treated	Redist. A. for Chem 1 Removed	Chem 2 Removed	Chem 3 Removed	Chem 4 Removed	Chem 5 Remove
FURADAN 4F	20	0				
Di-Syston 15-G	30	40	0			
Diazinon	15	20	40	0		
Mocap 6E	15	20	30	50	0	
Lorsban 4E	20	20	30	50	100	0

Total Revenue Change As Chemicals Are Deleted On
CORN FOR ROOTWORM IN DELAWARE.

Chemical	Net Benefit from Ap- plicaton	Quality/ Yield Adj from Deletion	Per Acre Change from Del.	Total Revenue Change for State from Deletion
FURADAN 4F	23.77	-11250 BU	-1.13	-16950
Di-Syston 15-G	12.56	22500 BU	5.26	78900
Diazinon	28.25	-15000 BU	-2.03	-30450
Mocap 6E	19.06	37500 BU	4.11	61650
Lorsban 4E	27.29	-225000BU	-27.29	-409350

1-NEXT 3-QUIT UNIVERSITY OF DELAWARE EXTENSION SYSTEM

APPENDIX B

Summary File Output Example

CARBOFURAN ASSESSMENT TEAM - ES/USDA COOPERATING
SUMMARY: 06-02-1989 13:49:24

Crop(s): CORN

Pest(s): ROOTWORM

State(s): DELAWARE
MARYLAND
NEW JERSEY

Acres planted: 1148000
Acres treated: 100000

Chemical	Quality/yield adjustment	Revenue change
FURADAN 4F	-75000	-113000
Di-Syston 15-G	150000	526000
Diazinon	-100000	-203000
Mocap 6E	250000	411000
Lorsban 4E	-1500000	-2729000

APPENDIX III

WILDLIFE MORTALITY BECAUSE OF THE PESTICIDE CARBOFURAN
INFORMATION REQUEST

This survey is being conducted as part of the USDA Pesticide Impact Assesment of Carbofuran. We appreciate your assistance. Please complete the RESPONDENT portion of the form even if you do not have any knowledge or documentation of wildlife mortality related to the pesticide Carbofuran. Please attach any additional records or pertinent information. The deadline for returning questionnaires is April 1. Thank you for your assistance in this project.

RESPONDENT:

NAME: ____________________

TITLE/AGENCY: ____________________

ADDRESS: ____________________

TELEPHONE:

1. Do you have documentation of wildlife mortality because of the pesticide Carbofuran? yes_____ no_____

   If the answer is no, please complete the RESPONDENT block and mail this form to the address on the reverse.

2. Wildlife mortality related to site and application of Carbofuran:

   Crop or site where pesticide was used: ____________________

   Formulation: ____________________

   Rate of Application: ____________________

   Time of Application: ____________________

   Method of Application: ____________________

   Was application in accordance with label directions? yes_____ no_____

3. List the wildlife species and number of individuals killed.

   ____________________ _____

   ____________________ _____

   ____________________ _____

   ____________________ _____

4. Were these wildlife species observed feeding on the pesticide? yes_____ no_____

5. Were these wildlife species observed feeding on the treated crop? yes_____ no_____

6. If the answer to questions 4 and/or 5 is yes, please indicate the name and address of observer.

NAME:____

TITLE:____

ADDRESS:______________________________________

TELEPHONE:____________________________________

7. Was residue analysis conducted to verify cause of death?
yes_____ no_____

8. Time following the application till mortality:
hours_____ days_____

9. List other factors that might have contributed to the wildlife mortality.

____

____

____

10. What recommendations or changes might have been made to prevent the hazard?

____

____

____

11. Are alternative pesticides or formulations of Carbofuran available that could have been used and prevented the wildlife hazard?

____

____

____

Thank you for your help and please return the questionnaire BY APRIL 1 to:

Gary San Julian
Department of Zoology
North Carolina State University
BOX 7617
Raleigh NC 27695-7617
(919) 737-2741

APPENDIX IV

Gary San Julian
Department of Zoology
North Carolina State University
Box 7617
Raleigh NC 27695-7617
(919) 737-2741

Table 1. Summary of responses to questionnaires sent to all states and territories regarding the use of carbofuran on field, pop, and sweet corn.

State or territory	Response received	Carbofuran used in state	Number of forms returned field corn	popcorn	sweet corn	Comments on usefulness of data
Alabama	yes	yes	2	0	0	Data for target insect pests could not be interpreted. Data for target nematode pests were acceptable.
Alaska	yes	no	-	-	-	
Arizona	yes	yes	1	0	0	Data could not be interpreted.
Arkansas	yes	yes	1	0	0	Data acceptable.
California	yes	no	-	-	-	
Colorado	yes	yes	2	0	0	Data acceptable.
Connecticut	no	---	-	-	-	
Delaware	no	---	-	-	-	
Florida	yes	yes	1	0	1	Data acceptable.
Georgia	yes	yes	1	0	0	Data acceptable.
Guam	yes	no	-	-	-	
Hawaii	yes	no	-	-	-	
Idaho	yes	yes	0	*	*	Data were for use of carbofuran in growing sweet corn seed and popcorn seed.

Table 1. (continued)

State or territory	Response received	Carbofuran used in state	Number of forms returned field corn	popcorn	sweet corn	Comments on usefulness of data
Illinois	yes	yes	2	0	0	Data acceptable.
Indiana	yes	yes	1	0	0	Data acceptable.
Iowa	yes	yes	2	0	0	Data acceptable.
Kansas	yes	yes	3	0	0	Data acceptable.
Kentucky	yes	yes	1	0	0	Data acceptable.
Louisiana	yes	yes	1	0	0	Alternatives to carbofuran not discussed, but effect on yield and quality if carbofuran is withdrawn were presented.
Maine	yes	no	-	-	-	
Maryland	yes	yes	1	0	0	Costs of treatments not given, but effect on yield and quality if carbofuran is withdrawn were presented.
Massachusetts	no	---	-	-	-	
Michigan	yes	yes	1	0	0	Data acceptable.
Minnesota	yes	yes	1	0	0	Data acceptable.
Mississippi	yes	yes	1	0	0	Costs of treatments not given and alternatives to carbofuran not discussed, but effect on yield and quality if carbofuran is withdrawn were presented.
Missouri	yes	yes	2	1	1	Alternatives to carbofuran not discussed, but effect on yield and quality if carbofuran is withdrawn were presented.

Table 1. (continued)

State or territory	Response received	Carbofuran used in state	Number of forms returned			Comments on usefulness of data
			field corn	popcorn	sweet corn	
Montana	yes	yes	1	0	0	Data could not be interpreted.
Nevada	yes	no	-	-	-	
Nebraska	yes	yes	1	0	0	Costs of treatments not given, but effect on yield and quality if carbofuran is withdrawn were presented.
New Hampshire	yes	yes	1	0	0	Data presented were for silage corn, not grain.
New Jersey	yes	yes	1	0	0	Costs of treatments not given, but effect on yield and quality if carbofuran is withdrawn were presented.
New Mexico	no	—	-	-	-	
New York	yes	yes	1	0	1	Costs of treatments not given for nematodes, but effect on yield and quality if carbofuran is withdrawn were presented. Insect data acceptable.
North Carolina	yes	yes	5	0	1	Data acceptable.
North Dakota	yes	yes	1	0	0	Data acceptable.
Ohio	yes	yes	1	0	0	Costs of treatments not given, but effect on yield and quality if carbofurna is withdrawn were presented.
Oklahoma	yes	yes	1	0	0	Data acceptable.
Oregon	yes	no	-	-	-	

Table 1. (continued)

State or territory	Response received	Carbofuran used in state	Number of forms returned: field corn	popcorn	sweet corn	Comments on usefulness of data
Pennsylvania	no	—	-	-	-	
Puerto Rico	no	—	-	-	-	
Rhode Island	yes	yes	1	0	0	Alternatives not discussed, but some yield loss data were presented. However, no corn data were given.
South Carolina	yes	yes	1	0	0	Data acceptable.
South Dakota	yes	yes	2	0	0	Data acceptable.
Tennessee	yes	yes	1	0	0	Data could not be interpreted.
Texas	yes	yes	1	0	0	Data not complete; could not use.
Utah	yes	yes	2	0	0	Data acceptable.
Vermont	yes	yes	-	-	-	Data not complete; could not use.
Virgin Islands	yes	no	-	-	-	
Virginia	no	—	-	-	-	
Washington	no	—	-	-	-	
West Virginia	yes	yes	1	0	0	Data not complete; could not use.
Wisconsin	yes	yes	1	0	0	Data acceptable.
Wyoming	yes	yes	1	0	0	Data not complete; could not use.

Table 2. Data for field corn.

State	Target pest(s)	Corn acreage	Avg. corn yield (bushels/acre)	Avg. price ($/bushel)
AL	nematodes	365,000	67	2.36
AR	soil insects	73,000	106	2.17
CO	corn rootworms European corn borer	828,750	134	2.45
FL	insects, nematodes	205,000	66	2.35
GA	soil insects	650,000	75	2.20
IL	soil insects European corn borer	10,000,000	120	2.30
IN	corn rootworms	5,640,000	124	2.10
IA	corn rootworms European corn borer	12,675,000	126	2.00
KS	nematodes European corn borer (1st) corn rootworms	1,152,500 1,300,000	130 120	2.17 2.24
KY	soil insects	1,420,000	100	2.21
LA	soil insects	226,250	154.5	2.98
MD	soil, foliar insects	672,500	95	2.28
MI	corn rootworms	3,000,000	100	2.00
MN	soil insects	6,613,000	117.8	1.88
MS	soil insects	240,000	80	2.70
MO	soil insects European corn borer	2,205,000	105	2.28
NE	soil insects	6,500,000	131	2.50
NJ	soil insects	135,000	98	----
NY	corn rootworms	1,300,000	100	2.33

Table 2. (continued)

State	Target pest(s)	Corn acreage	Avg. corn yield (bushels/acre)	Avg. price ($/bushel)
NC	nematodes European corn borer soil insects	930,000 1,570,000	84 76	2.95 2.75
ND	soil insects	905,000	81	1.97
OH	soil, foliar insects	3,700,000	125	2.00
OK	corn rootworms	76,000	108	2.44
SC	soil insects	350,000	70	2.40
SD	European corn borer corn rootworms	3,500,000	73	2.35
UT	soil insects foliar insects	76,000	124.5	2.58
WI	soil, foliar insects	4,161,000	110	2.50
Total		68,386,500*	---	---
Average		---	103.2	2.32

*Where 2 total corn acreages are given for one state, the larger number was used to calculate the overall total.

Table 3. Summary of results from questionnaires regarding the use of carbofuran to control the soil insect complex in field corn.

State	% acres treated with carbofuran	Total acres treated with carbofuran	% acres treated with alternatives*	Total acres treated with alternatives*
AR	65	47,450	25	18,250
CO	10	82,875	51	422,663
GA	8	52,000	12	78,000
IL	2	200,000	37	3,700,000
IN	3	169,000	24	1,353,600
IA	3	380,250	33	4,182,750
KS	7	195,000	65	845,000
KY	4	56,800	21	298,200
LA	50	113,125	--	----
MI	9.1	273,000	18.4	552,000
MN	2.35	155,901	18.15	1,200,260
MS	25	60,000	--	----
MO	2.35	52,973	57	1,282,500
NJ	3	4,050	12	16,200
NY	10	130,000	23	299,000
NC	17	271,505	45	706,725
ND	5	45,250	25	226,250
OK	25	19,000	55	41,800
SD	1	35,000	18	630,000
UT	9	6,840	31	23,560
Total		2,350,019		15,876,758

*Chemical alternatives

Table 4. Summary of results from questionnaires regarding the use of carbofuran to control European corn borers in field corn.

State	% acres treated with carbofuran	Total acres treated with carbofuran	% acres treated with alternatives*	Total acres treated with alternatives*
CO	1	8,288	20	165,750
IL	1.5	150,000	1.5	150,000
IA	1	126,750	3	380,250
KS	7	91,000	15	195,000
MO	1	22,500	4	90,000
NC	5	78,500	0	----
SD	5	175,000	5	175,000
Total		652,038		1,156,000

*Chemical alternatives

Table 5. Summary of results from questionnaires regarding the use of carbofuran to control nematodes in field corn.

State	% acres treated with carbofuran	Total acres treated with carbofuran	% acres treated with alternatives*	Total acres treated with alternatives*
AL	12	43,800	12	43,800
KS	5	57,625	0	---
NC	10	93,000	0	---

*Chemical alternatives

Table 6. Summary of results from questionnaires regarding the use of carbofuran to control a combination of pests in field corn.

State	% acres treated with carbofuran	Total acres treated with carbofuran	% acres treated with alternatives*	Total acres treated with alternatives*
FL	25	51,250	15	30,750
MD	15	100,875	11	73,975
NE	7.8	507,000	52.2	3,393,000
OH	5.1	188,700	33	1,221,000
SC	15	52,500	80	280,000
WI	0.6	24,966	39.4	1,639,434
Total		925,291		6,638,159

*Chemical alternatives

Table 7. Summary of results from questionnaires regarding acres of field corn that are not treated for specified target pests.

State	Target pest(s)	% acres not treated for target pest(s)	Total acres not treated for target pest(s)
AL	nematodes	76	277,400
AR	soil insects	10	7,300
CO	soil insects	39	323,213
	European corn borer	79	654,713
FL	nematodes, insects	60	123,000
GA	soil insects	80	520,000
IL	soil insects	61	6,100,000
	European corn borer	97	9,700,000
IN	soil insects	73	4,117,200
IA	soil insects	64	8,112,000
	European corn borer	96	12,168,000
KS	nematodes	95	1,094,875
	European corn borer	78	1,014,000
	soil insects	20	260,000
KY	soil insects	75	1,065,000
LA	soil insects	1	2,263
MD	insects	74	497,650
MI	soil insects	72.5	2,175,000
MN	soil insects	79.5	5,257,335
MO	soil insects	40.65	914,625
	European corn borer	95	2,137,500
NE	insects	40	2,600,000
NJ	soil insects	85	114,750
NY	soil insects	67	871,000
NC	nematodes	90	837,000
	European corn borer	95	1,491,500
	soil insects	38	596,790
ND	soil insects	75	678,750
OH	insects	61.9	2,290,300
OK	soil insects	20	15,200
SC	insects	5	17,500
SD	soil insects	82	2,870,000
	European corn borer	90	3,150,000
UT	soil insects	60	45,600
WI	insects	60	2,496,600

Table 8. Summary of economic analyses regarding the use of carbofuran to control the soil insect complex in field corn.

State	Acres currently treated with carbofuran	Overall change in net return (per acre) if carbofuran is withdrawn and alternatives are used	Net return for state
AR	47,450	- $11.08	- $ 525,746
CO	82,875	No change	No change
GA	52,000	+ $ 2.49	+ $ 129,480
IL	200,000	- $ 0.08	- $ 16,000
IN	169,000	+ $ 1.68	+ $ 283,920
IA	380,250	+ $ 1.13	+ $ 429,683
KS	195,000	+ $ 2.40	+ $ 468,000
KY	56,800	- $ 0.20	- $ 11,360
MI	273,000	+ $ 1.85	+ $ 505,050
MN	155,901	+ $ 7.77	+ $1,211,351
MO	52,973	+ $ 0.25	+ $ 13,243
NJ	4,050	+ $ 0.30	+ $ 1,215
NY	130,000	No change	No change
NC	271,505	- $ 1.05	- $ 285,080
ND	45,250	- $ 0.13	- $ 5,883
OK	19,000	- $ 9.72	- $ 184,680
SD	35,000	No change	No change
UT	6,840	- $21.74	- $ 148,702
Total			+ $1,864,491

Table 9. Summary of economic analyses regarding the use of carbofuran to control European corn borers in field corn.

State	Acres currently treated with carbofuran	Overall change in net return (per acre) if carbofuran is withdrawn and alternatives are used	Net return for state
CO	8,288	No change	No change
IL	150,000	- $ 3.55	- $ 532,500
IA	126,750	- $13.40	- $1,832,450
KS	91,000	+ $ 1.27	+ $ 115,570
NC	78,500	- $ 2.09	- $ 164,065
SD	175,000	+ $ 2.40	+ $ 420,000
Total			- $1,993,445

Table 10. Summary of economic analyses regarding the use of carbofuran to control a combination of pests in field corn.

State	Acres currently treated with carbofuran	Overall change in net return (per acre) if carbofuran is withdrawn and alternatives are used	Net return for state
FL	51,250	- $24.67	- $1,264,338
MD	100,875	- $ 0.99	- $ 99,866
NE	507,000	+ $ 0.95	+ $ 481,650
OH	188,700	+ $ 0.27	+ $ 50,949
SC	52,500	No change	No change
WI	24,966	+ $ 0.63	+ $ 15,729
Total			- $ 815,876

APPENDIX V

9-28-89

OUTLINE FOR PESTICIDE USE BENEFITS ASSESSMENT REPORT

Title/Cover Page

Table of Contents

Executive Summary (Appendix A-1)

- Purpose of report
- Special review triggers (EPA)
- Methodology
- Summary of findings and conclusions (Appendix A-2):
    - Concise tabular presentation of use data and alternate use data (Appendix A-3)
    - Benefits and impacts of pesticide use cancellation
    - Benefits and impacts of pesticide use continuation

I. Introduction (Appendix B-1)

A. Cooperative effort statement (USDA, CES, and EPA) (Appendix B-2)
B. Purpose (in detail) (Appendix B-3)
C. Assessment team
   1. Role
   2. Member names, expertise, and affiliation
D. Acknowledgements and affiliations
E. Description of document that follows
F. Definitions (Special terms, acronyms)

II. Pesticide Characteristics

A. History and development, formulations (Appendix C)
B. Physical and chemical properties, mode of action (Appendix D)
C. Environmental fate and degradation properties (Appendix E)
D. Physiological activity of pesticide in soil, water, air and fate in plant tissue (If appropriate--physiological metabolism and toxicology in humans/animals) (Appendix F)
E. Principle uses (General) (Appendix G)
   1. Amounts (Acres or animals), areas treated in U.S.
   2. Current, world-wide, and future use patterns (If mutually beneficial--joint reports between countries, e.g., U.S. and Canada)

III. Methodology of Benefits Assessment Report

A. Data collection (survey techniques) Appendix H)
B. Criteria for Specialists selection (Appendix I)
C. Assumptions (Appendix J)
D. Limitations (Include data gaps and research needs) (Appendix K)

IV. Specific Use Analyses

A. Current Registered Uses of the Pesticide <u>by Site/Commodity</u> (All major and minor uses)

1. Registration summary

2. Pest damage and infestation information (controlled and uncontrolled situations)

3. Pest management recommendations (summary of relevant literature)

4. Actual on-farm use data (Appendix L):
   a. Percent of site/commodity treated and area of the country
   b. Variability in usage--year-to-year and area of country
   c. Frequency of application and number of applications per growing season
   d. Active ingredient applied per unit area (Note variability)

5. Crop systems and practices
   a. Age of crop at treatment
   b. Application methods
   c. Proximity of non-treatment crops and environmental situations
   d. Relationship between pesticide uses and cropping systems (crop rotations)
   e. Integration of pesticide use with good management practices

6. Potential for Pest Resistance

B. Alternative Management Practices <u>by Site/Commodity</u> (IPM, Other Chemical, and Non-chemical uses)

Follow points 1-6 above, include economic/social impacts and compare effectiveness with review pesticide

C. Economic and Social Impacts <u>by Site Commodity</u> (Appendix M)
   1. Methodology and data (crop yield/quality, efficacy/value)
   2. Quantitative use analysis of the review pesticide and/or alternative(s)
   3. Comparative cost-effectiveness of the review pesticide use and/or alternatives (Treatment costs, net change in production costs/returns)
   4. Impacts of non-use (cancellation) of the review pesticide and non-use of any alternative(s)
   5. Commodity/market impacts
   6. Consumer impacts
   7. Related economic impacts (including macro-economic considerations)
   8. Social/community impacts

V. Exposure Considerations (Biological effects) (Appendix N)
   A. Impact on non-target organisms
   B. Impact on agricultural workers, applicators (see pp. 109-119 of Benomyl Report)
   C. Impact on water quality
   D. Residual control effects
   (Reference all incidents with proper documentation)

VI. Conclusions and Recommendations (Integrated summary)

VII. Appendices

VIII. References (Full citations listed numerically for the entire report)

Prepared by Dale Miller, ES-USDA/University of Maryland CES

References:

Bergman, P. and A. Padula. NAPIAP communications, 1988-89.

Curtis, C.R. Agricultural Benefits Derived From Pesticide Use: A study of the assessment process, Ohio State University. 1988.

Ethyl Parathion Benefits Assessment Report outline and notes, 1988.

Pesticide assessment reports (Benomyl, Chlordimeform (umpublished), DBCP, Dimethoate, Lindane)